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* * *

CHEMISTRY DIVISION - PROTECTIVE CHEMISTRY SECTION

14 August, 1945

CHAMBER TESTS WITH HUMAN SUBJECTS
IX. BASIC TESTS WITH H VAPOR

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~~Report P-2579~~ NRL 2579

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NRL Problem P-60-3

ABSTRACT

This report describes the results of exposures to H vapor of men wearing ordinary clothing and unprotected except for masks and, in some cases, protective shorts, over a wide range of exposure conditions. Various methods for the evaluation of the results obtained are presented and discussed.

The severity and locations of burns from a given CT of H vapor were markedly influenced by the temperature of exposure. At low temperatures (70° F.,) active sweat secretion and H vapor burns were predominantly in the axillary and genital regions. At high temperatures (90° F.), both sweating and H vapor burns were generalized. The threshold temperature for generalized sweating, and consequent increased susceptibility to H vapor, was approximately 85° F. for lightly clothed, resting men. Variation in relative humidity had the most pronounced effect on susceptibility to H vapor at 85° F.

Conditioning of the men before exposure, either artificially or because of climatic conditions, had a significant effect on the reactions produced from exposure to H vapor. Suppression of sweating by application of aluminum chloride to the axillae prior to exposure, reduced the severity of the resulting H burns. The application of lanolin to the skin prior to exposure had no effect on the resulting H burns, whereas wetting of the skin with artificial sweat increased the severity of the burns.

The scrotal region was the most vulnerable area of the body to H vapor and would be the most important area in the production of casualties. It was found that ulcerated and crusted lesions of the penoscrotal region required from three to four weeks to heal with the men at bed rest.

KEY WORDS

Aluminum Chloride, Antiperspiants, Chamber tests, Human subjects H vapor, Mustard gas, Chemical warfare, Chlothing, Erythema, Exposure, Humidity, Persistance, Contamination, HN vapor, Impregnated chlothing, Lanolin, Levenstein H, Nitrogen mustard, Physiological effects, Toxic agents, Vesicants.

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INTRODUCTION

A. Authorization.

1. This work was authorized under Project No. 547/41, "Maintenance, Bureau of Ships" dated 16 December 1940. The problems which were proposed for study were given in BuShips letter S-S77-2(Dz), serial 811 of 17 December 1940.

2. Participation of volunteer Naval personnel in tests for the study of vesicant gases was approved by the Secretary of the Navy (Acting Sec. Nav. ltr. to OSRD dated 8 May 1942). Performance of such tests at the Naval Research Laboratory was approved by the Chief of the Bureau of Medicine and Surgery (BuMed ltr Serial No. 446 X:OA A11/EH10(430320)(SC) dated 20 March 1943).

B. Statement of Problem

3. This investigation was undertaken to determine the effect of H vapor at different concentrations, and at various conditions of temperature and relative humidity, on men wearing gas masks and ordinary clothing. The results obtained would serve two purposes, namely, a more complete knowledge of the effects which would be expected from an H attack in the field, and also, by comparison with other chamber data, a more adequate evaluation of the protection afforded by different types of protective clothing under diverse conditions. During the course of the investigation, it became evident that it would be worth-while also to determine the extent of sweating of different areas of the body under various conditions of temperature and relative humidity and to correlate the results with those obtained by exposure to H vapor under the same conditions.

C. Known Facts Bearing on the Problem.

4. It has generally been recognized that when men are exposed to H vapor:

(1) Ordinary clothing offers very little protection;
(2) Increase in CT, by increasing either the concentration of the agent or the time of exposure, increases the severity of the skin reaction;
(3) At a given concentration, more severe reactions occur at higher temperatures and humidities, in summer, and during exercise;
(4) In any individual, marked differences exist in the susceptibilities of many of the body regions; and
(5) There is also considerable variation in the susceptibilities of different individuals.

5. Little precise information pertinent to the above statements or the mechanisms involved has been available. However, it is suggested in much of the available literature that, directly or indirectly, the susceptibility of the skin to H vapor is closely related to the sweating process.

6. In C.D. (Australia) Report No. 40 dated 22 May 1944, it is stated that men exposed in the chamber to H vapor at CT 150-200, 90° F., and 62-85% RH, received severe generalized erythema. The men were regular clothing and were sweating profusely during exposure so that their clothing was saturated with sweat. Exposure at similar CTs at 70° F., 66-95% RH, affected

mainly the neck, axillae, and scrotum, but two-thirds of the men showed generalized erythema. The skin of these latter men was described as damp and the clothing as dry. All subjects performed moderate exercise while in the chamber. The writers concluded that temperature played an important part in determining the severity of the lesions but that, within the range tested, humidity played no significant role. In C.D. (Australia) Report No. 41, dated 19 May 1944, it is stated that exercise of the subjects, during field or chamber exposure to H vapor, plays an important part in increasing the severity of the lesions.

7. Experiments carried out at Porton indicated that the important factor in increasing the susceptibility is the moisture present on the skin surface, but no correlation was found between skin temperature and physiological effects.

8. By means of exposures of human forearms on the vapor train at UCTL, Dr. Simon Black, et al, have demonstrated that H vapor in moist air caused much more severe reactions than H vapor in dry air at any given CT. Sweating skin was found to be somewhat more susceptible than non-sweating, but the difference was slight compared to the increased susceptibility when the H vapor was in moist air rather than in dry (OSRD Report No. 3944, dated 30 August 1944).

9. In C.D.R.E. (India) Report No. 285, dated 29 November 1944, it is reported that two men, wearing tropical battledress suits and CC-2 impregnated shorts, were exposed in a chamber to H vapor at an integrated CT of 750 (T=16 minutes), 87° F., and 84% RH. The men who had been exercising so that their clothing was sweat-saturated at the time of entry into the chamber, sustained generalized second degree burns with edema and vesication and were both incapable of further military duties for four hours to fourteen days after exposure.

10. At the University of Chicago Toxicity Laboratory, studies have been made of the vesicancy of HN3 smokes on the forearm held in the wind tunnel (NDRC, Division 9, Informal Monthly Progress Report No. 9-4-1-23 dated 10 December 1944). Since active secretion of sweat lowers electrical resistance of the skin, skin resistance measurements were taken. "In any single run it was possible to predict which man would develop more severe reactions on the basis of skin resistance measurements. The predictions are much less reliable between runs and do not appear to be useful between profusely sweating observers and those at the incipient sweating level."

11. In Porton 1601 A(V.1358) dated 7 February 1945, chamber tests on resting men (presumably not showing generalized sweating) at even higher CTs [CT 1190 (T=85 minutes), 58° F., 59% RH and CT 1860 (T= 60 minutes, 47° F., 57% RH] are reported. Intense reactions were observed on the necks and axillae, and edema and vesication of the penis occurred in most of the men. Reactions on the rest of the body were much milder. Similar results were obtained with CT 1170 (T= 6 1/2 Minutes), 58° F., 59% RH, and it was concluded "that the rule CT=constant had been demonstrated with sufficient accuracy" for men wearing plain clothing.

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12. In OSRD Report No. 5169, "Observations on the Role of Water in the Susceptibility of Human Skin to Vesicant Vapors", dated 12 April 1945, Renshaw has reviewed the literature pertinent to the mechanism by which sweating skin is more susceptible to H vapor and has performed some original experiments. He found that the skin of the arms of men who were not visibly sweating suffered a greater injury from H vapor (applied by vapor cups) if the skin were wet with a film of distilled water at the time of vapor exposure than if the skin were "unwetted" or "dry". Increased susceptibility was not observed if the wetted skin were allowed to dry before exposure to H vapor. Wetting the skin after H vapor exposure did "not markedly influence the severity of the injuries which subsequently developed". No marked difference was found if the skin were wetted with 4% NaCl instead of distilled water. It was concluded that the presence of water on and in the surface layers is, to a considerable degree, responsible for the well known heightened susceptibility of hot, sweating skin to H vapor.

13. Recent man-chamber tests conducted by Lt. Comdr. J. F. Troxel, MC. USN(Ret.), at UCTL (Informal Report No. N.S. 1, dated 15 April 1945), which are especially significant because of the large numbers of subjects employed, demonstrated that, at any given temperature, an increase in relative humidity resulted in an increased severity of reaction to H vapor at CT 100. Conversely, at any constant relative humidity, a rise in temperature also resulted in an increased severity. The greatest increase in severity for a 10° F. rise in temperature occurred between 80° F. and 90° F.

II. Theoretical Considerations

14. Recording and evaluation of data. Almost every group studying the effects of vesicants on human volunteers employs a different system of nomenclature, recording, and evaluation of data. While a more uniform method would be desirable, it is also evident that particular problems involve different considerations, e.g. studies on unprotected men as compared with those in which protective clothing is worn and studies on small skin areas as compared with those in which total man exposure is employed.

15. This problem has been cogently discussed by the Physiology Section of A.F.E.S. under Lt. Col. F. Gorrill in Phys/C/5, an interim discussion "on Reporting Results of Human Exposure to Vesicant Vapor", dated 25 January 1945. In this discussion, it is recommended that the body surface be divided into a given number of anatomical regions and scoring be done "on the basis of maximum lesion sustained by the subject in any given area, irrespective of the time at which it occurs".

16. In C.D. Australia 55, by Lt. Sinclair dated 18 October 1944, the effects under tropical conditions of H vapor from CT 50 to 765 on 98 men under varying conditions of exposure time, temperature, and RH have been considered. Lesions for each area have been evaluated by a coefficient which combines incidence and severity (number of men affected in that region x the mean score per lesion). This method was used for a given region, but was not used to assess the total severity of reaction of a group of men under specific conditions of temperature and RH.

17. A similar system has been in use at NRL which combines incidence and severity for a region. The average sum of this product for all the regions represents the total damage index for a given set of conditions. Recently it has been found desirable to increase the number of body subdivisions described in taking readings although these may be condensed later to facilitate comparison with older data.

18. The index for a given region should probably take the following factors into account:

(1) Intensity of reaction
(2) Area of skin represented by a region
(3) Casualty effect
(4) Regional susceptibility
(5) Individual variation

19. Intensity of reaction. The scale of readings used at this Laboratory has developed gradually and while the terminology is somewhat clumsy, it has been found satisfactory for subsequent translation into numerical values. Since most of the studies in this report involve no damage greater than a severe erythema (except for the axillae and genital region) it is evident that the description of severity is quite different than for the more severe effects observed by the Australian group. It would be ideal to incorporate the time to reach maximum severity and the healing time into an index, but the complexity introduced indicates it is better to treat these factors descriptively.

20. Area of skin represented by a region. It is well known that the total skin area involved is highly important in thermal burns (and probably for chemical burns) in determining the degree of shock produced. The striking differences in area involved in reactions to mustard vapor at high and low temperatures made it evident that it would be desirable (for special studies) to introduce a factor weighting areas so that regions of totally different areas like the thigh and axilla would not be weighted equally in the index. The factors used in the present report are highly arbitrary, but have been helpful in expressing the area effect. It is felt that the maximum reading for any area is adequate and that it would be impractical to attempt to delimit the readings any further.

21. Casualty effect. Casualty effect would be a desirable and most practical factor in an index. It has been impossible to evaluate this in the present work except on a descriptive basis. Most of the experiments in this series did not result in true casualties, except those which caused lesions of the axillae and scrotum which will be discussed below. Outstanding studies in the evaluation of casualties with great practical importance have been carried out by the Australian group.

22. Regional susceptibility. It would be ideal if the threshold CT required to produce erythema and vesication were accurately known for each region under a given set of conditions. It would be of interest to know if the ratio of erythema level to vesication level is constant for different regions. Adequate data are not available to ascertain this.

23. Individual variation. A simple test to predict how a given individual will react to H vapor has not been developed. The influence of this variable must still be minimized by using as many men as possible in each test.

E. Previous Work Done at this Laboratory.

24. NRL Report No. P-2208 dated 22 December 1943 contains a description of the design and operation of a chamber for exposing human subjects to known concentrations of H vapor under controlled conditions of temperature and humidity. NRL letters to BuShips, C-S77-2(459-HWC), C-459-604 dated 20 October 1944 and C-S77-2(459-HWC/JHH), C-459-119/45 dated 10 March 1945, include a preliminary report on the effects of CT, temperature, and relative humidity on the reactions of men exposed to H vapor when wearing ordinary clothing. In the present report, all the basic tests with H vapor carried out at this Laboratory to May 1945, are summarized.

EXPERIMENTAL PART

Part I - Procedure.

A. Basic Tests with H Vapor.

25. Basic tests, as defined at this Laboratory, are tests with vesicant vapors carried out on men wearing ordinary clothing and unprotected except for masks and, in some cases, protective shorts.

(1) General Procedure for Basic Tests.

26. Test subjects. The men used in these tests were volunteer Naval personnel from USNTC, Bainbridge, Maryland, and were usually seamen second class, from eighteen to twenty years of age who had just completed their "boot" training. Most of their homes were in the Atlantic Seaboard States, both north and south of Washington, D. C. All men received a routine physical and laboratory examination (blood and urine) and only those approved by a medical officer participated in the experiments. At the end of the tests, the men were granted special leave and an entry was made in their service records attesting their attendance at this activity. Recently, authorization has been granted for the commanding officer to give commendation to especially deserving individuals.

27. Clothing. During chamber exposure, the men were standard issue skivvy shirts and Nainsook shorts, watch caps, blue denim shirts, dungaree pants, standard socks and shoes. Shirt collars were buttoned and shirt sleeves were buttoned at the wrist. All men wore ND Mark III or IV masks. In some of the tests, the Nainsook shorts were replaced by CC-2 impregnated shorts. These latter were of the rib-knit type, impregnated by the aqueous process, and contained about 0.5 mg. Cl^+/cm^2. In all tests since 1 January 1945, the men have worn suspenders made of carbon coated cloth (August model). The protection afforded by these suspenders causes a subjacent area of relatively normal skin which contrasts with the erythematous areas and facilitates observations (Fig. 35, Plate 10). Subjects dressed for a basic test are illustrated in Fig. 1, Plate I.

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28. The chamber. The chamber has been described in detail in NRL Report No. P-2208. Briefly, it is 10 feet by 15 feet by 12 feet high and has a volume of 1800 ft.^{3}. It is operated as a static chamber, no air being passed through during a test, but the air present is kept in motion (average velocity = 2.0 m.p.h.) by suitable fans.

29. Concentration of agent. Volatilized redistilled thiodiglycol mustard was introduced into the chamber as needed to establish and maintain the desired concentration on the basis of Northrop titrimeter analyses (bromine method) which were made every five minutes. The average concentrations of H vapor in this series of tests varied from 1.67 to 11.7 micrograms H/liter.

30. Time of exposure. All basic tests were single exposure tests. In all cases the time of exposure was 60 (± 2) minutes except the two tests at CT 50 in which the exposure time was thirty minutes.

31. CT. CT represents the product of the concentration of the agent and the time of exposure; and where the units are not expressed, is understood to be in microgram minutes per liter. In this series of tests, the CT employed was varied from 50 to 700. A complete list of these CTs is presented in Table III.

32. Temperature and relative humidity (RH). The chamber temperature was elevated by electric heaters, and was lowered by means of ice. Humidification was accomplished by the introduction of steam; dehumidification, by the use of ice. Both temperature and humidity were regulated and recorded by a two-point Brown recording controlling potentiometer which operated through wet and dry bulb thermocouples. All temperatures given are dry bulb temperatures of the ambient air expressed in degrees Fahrenheit; Measurements of radiant energy effects have not been made.

33. Activity in the chamber. The men stood at ease in the chamber, but were required to change positions about every five minutes. No tests on the effects of exercise during chamber exposure are included in this series.

34. Activity before and after chamber exposure. In general, before and after chamber exposure, the men led a relatively sedentary existence with occasional mild athletics. In none of the tests in this series were the men assigned to strenuous work after chamber exposure.

35. Season and climate. The majority of the tests were performed as listed in Table III (Page 13), when the weather was relatively cool. Tests 2, 4, 8, 13 and 16 were carried out under the hot summer weather conditions of Washington, D. C. The chamber exposures were usually performed between the hours of 1000 and 1500, i.e. during the warmer part of the day. When the weather was fair, the men were allowed to be out of doors before and after chamber tests; when the weather was cold or inclement, the men were kept indoors at the conditions prevailing in the Laboratory.

36. Daily readings and the recording of data. The men were inspected daily by a medical officer for four to eight days or longer after exposure. To facilitate recording and subsequent use of data, subdivisions of the body surface were listed as ordinates on graph paper (one-quarter inch squares) and daily intensity readings for these areas were recorded as abscissae. A List of the body regions is given in Table I (page 10).

37. Photography. Kodachromes were taken of many of the groups of men used in the basic tests. These were usually taken on the fourth day after exposure; subsequent pictures were taken when deemed necessary. More satisfactory pictures were obtained after the skin had started to pigment since mild degrees of erythema did not show enough contrast on the pictures. It must be emphasized that kodachromes alone are not adequate records and that the daily readings are a more reliable reference for following the intensity of reaction. Inadequate illumination may lead to under-exposure of certain skin areas with a resultant apparent erythema which is an artefact. The prints which are included in the appendix were prepared by the Ansco "Printon" process. The larger ones were prepared from 4 x 5 inch transparencies; the smaller, from 35 mm. transparencies.

(2) Special Basic Tests.

38. Effect of environmental temperature immediately prior to chamber exposure. During the summer, the men were necessarily warm and often sweating at the time of entry into the chamber. When the weather was cool or cold, the men were usually indoors at a comfortable room temperature for one to two hours (or more) prior to exposure. Tests 24 and 25 (Table III) were carried out to see if precooling had any effect on the reactions from chamber exposure. Five men were exposed nude to a temperature of 55° to 60° F., approximately 65% RH, for over two hours prior to entering the chamber. Five other men remained clothed and at a comfortable room temperature, approximately 75° F. and 50% RH, for a similar period before exposure. Both groups donned fresh clothing, including CC-2 impregnated shorts, and were exposed in the chamber simultaneously to H vapor at CT 300, 90° F., 65% RH.

39. Use of aluminum chloride. To suppress axillary sweating, in Test 28 (Table III), a 25% aqueous solution of aluminum chloride was applied with a cotton pledget once daily to the left axilla of each man in the group for three successive days before he entered the chamber.

40. Use of lanolin. Since H is lipoid soluble, it was considered possible that the presence of sebum on the surface of the skin might influence the susceptibility of the skin to H vapor. To simulate sebum, lanolin (hydrated approximately 50%) was used. A thin film was applied shortly before entry to the chamber over an area of about thirty square centimeters on the forearm, posterior neck, and posterior shoulder of the men in Test 28, who were exposed to CT 500, 70° F., 48% RH. In a later test (Test 24), in which the men were exposed to CT 300, 90° F., 65% RH, lanolin was applied to the forearm, posterior shoulder, posterior neck, and left axilla. No men took showers for at least four hours after exposure in the tests in which lanolin was used.

41. Artificial wetting of the skin. On the basis of Dr. Renshaw's informal report on the effects of H vapor on simulated wet, sweating skin, the following experiment was performed. Standard skivvy shirts were treated with paraffin wax so that a waxed strip about two inches wide extended vertically the length of the shirt in the midline front and rear.

One-half of the shirt was thoroughly moistened with artificial sweat,* the other half was left dry. These skivvies were then donned by six men who also wore denim shirts and the usual clothing for basic tests (including CC-2 impregnated shorts). The environmental temperature was sufficiently low so that the men did not show generalized sweating prior to entry into the chamber. These non-sweating men were exposed to H vapor at CT 300, 70° F., 45% RH on 2 April 1945.

(3) Evaluation of Data.

42. Since it is impractical to present a detailed description of each subject in every test, an attempt has been made to present the data quantitatively so that the results may be more readily visualized. Each degree of reaction was given an arbitrary numerical value as follows:

0 = no reaction
1 = mild erythema
2 = moderate erythema
3 = intense erythema
4 = a. Erythema with edema
b. Maceration of axillary skin
c. Dry scaling of scrotum
5 = a. Vesicle
b. Numerous pinpoint vesicles
c. Crusting or ulceration of scrotum or axilla.

43. From these numerical values, three quantitative methods of treating data were devised which are considered in this report; (1) Maximum severity; (2) Total damage index; and (3) Percentage of exposed area affected. Special cases, such as lesions of the scrotum, are discussed separately.

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FOOTNOTE:

* The synthetic sweat solution was prepared according to a formula supplied by Dr. Dana Burks and is approximately five times as concentrated as that secreted by the glands.

Constituent	Concentration gms.or cc./100 cc.
Sodium chloride	3.65
Ammonium acetate	0.33
Urea	0.47
Dextrose	0.085
Potassium chloride	0.48
Magnesium chloride	0.036
Potassium dihydrogen phosphate	0.045
Calcium carbonate	0.065
Lactic acid (85%)	0.1

Five drops each of formic acid, acetic acid, butyric acid, propionic acid, methylamine and trimethylamine.

44. Maximum severity. This method has been used at this Laboratory and has been described in previous letter reports (NRL letter C-S77-2(459-HVC) C-459-604 dated 20 October 1944). The average maximum severity recorded over a period of several days after exposure, regardless of the region of the body affected, was taken to represent the effect of the agent on the body under a given set of conditions. A satisfactory relationship between CT and intensity of reaction could be demonstrated using this method as long as all tests were conducted at 90° F., 65% RH. However, when the temperature and RH were varied, it was found that the maximum severity method was no longer applicable since men with an obvious difference in reaction to the agent might, nevertheless, have the same maximum reading. For example, one man might have as a maximum reading an intense erythema of the axillae with essentially no burns elsewhere and another man might have an intense erythema over most of his body. By the maximum severity method of evaluation, both men would be classified as the same. Figure 4, Plate 3 gives an illustration of this since the men who do not show generalized erythema did have intense erythema of the axillae.

45. Total damage index. Since it was observed that often men exposed to H vapor at various conditions of temperature and RH differed in their reactions mainly in the areas of skin affected rather than in the intensities of reaction, and since it is common knowledge that the total area of skin affected is a highly important factor in determining systemic reactions to thermal burns, it was felt desirable to obtain an approximation of the percentage represented by a given body region of the total area exposed in a test. In order to facilitate use of older data, the areas were combined in the manner shown in Table I. These areas were then marked off with ink in arbitrary fashion on ten men of various weights and statures. The regions were measured and their areas were calculated according to the simplest geometric form represented. Their sums represent the total area considered in the basic tests, and each region has been represented as a percentage of this sum. These percentages are called "area factors" and are listed in Table I. It is of interest that for any given man, this sum represents 73 ± 6% of his theoretical total body area as obtained from standard height-weight nomograms. Although these area factors represent only a crude approximation and are highly arbitrary, it is felt that they are useful in evaluating the data obtained from the basic tests.

46. In calculating the total damage index, the intensity scale mentioned in paragraph 42 was used. The intensity factor for a given area in a test represented the average maximum reading for that area for that group of men. The product of the intensity factor and the area factor described above gives the total damage for that area for the group under consideration. The sum of these products for the eighteen areas considered represents the total damage index. An example of the method employed is given in Appendix B. In order to compare data on men who were protective shorts with data on those who did not, it was necessary to subtract from the final index the figures for those areas on the unprotected men which would have been covered had shorts been worn.

TABLE I

Body Regions Described in Daily Readings

Complete List	Abbreviation	Summarized List	"Area Factor" Percentage of total exposed skin represented by each region*
Anterior neck	ane		
Posterior neck	pne	ne	2.4%
Lateral neck	lne		
Anterior shoulder	ash		
Posterior shoulder	psh	sh	5.9%
Anterior axillary fold	aaf		
Axillae	ax	ax	2.8%
Posterior axillary fold	paf		
Scapulae	sc		
7th cervical vertebrae	C7	sc	3.3%
Ventral thorax	vth	vth	6.0%
Lateral thorax	lth	lth	3.5%
Dorsal thorax	dth	dth	5.3%
Upper abdomen	uab		
Lower abdomen	lab		
Iliac	il	abd	11.1%
Lumbar	lum		
Inguinal region	ing	ing	2.4%
Penis	pen	pen	1.1%
Scrotum	scr	scr	1.1%
Buttocks	bt	bt	6.3%
Anterior arms	aar		
Forearms	fa		
Posterior arms	par	ar	14.6%
Elbows	el		
Cubital fossae	cf	cf	0.9%
Dorsal hands and wrists	wr	wr	1.4%
Anterior thighs	athi		
Knees	kn	thi	22.4%
Posterior thighs	pthi		
Popliteal fossae	pop	pop	1.7%
Anterior leg	alc		
Posterior leg	plc	lc	7.7%
			99.9%

* See paragraph 45.

47. Percentage of exposed area affected. This expression was developed primarily to emphasize the difference between exposures at high and low temperatures. The number of men in any one group showing a moderate erythema* or greater on any particular area was multiplied by the corresponding area factor. The sum of these products for the eighteen areas divided by the number of men in the group for any given test represents the average percentage of the total skin surface exposed showing moderate erythema or worse. This expression likewise must be corrected for comparison with those groups which did not wear protective shorts. It should be emphasized that since the area covered by the shorts represents about 11% of the exposed surface, the maximum figure possible after correction is 89% and not 100%. An example of the method employed in this calculation is given in Appendix C.

B. Sweat Tests.

48. The starch-iodine method of Minor was used to demonstrate sweating at the various conditions of temperature and relative humidity used in the tests. An iodine solution (15 g. iodine, 15 g. potassium iodide, 100 ml. castor oil and 95% ethanol to make one liter) was applied to the entire body with a cotton pledget. After the iodine solution had dried, soluble starch powder was applied with a powder duster or cotton puff. Immediately after the application of the iodine and starch the men donned clothing and masks and remained in the chamber for one hour at the prescribed conditions. If sweat secretion occurred, the starch and iodine dissolved and reacted, changing color of the skin from a light brown to a dark purple. Except for the absence of H vapor in the chamber, the test conditions were identical with those of the basic tests described above. Since the men wore dungarees during the exposure to H vapor, it was considered a more comparable test to have them wear dungarees for the sweat test, although clothing did tend to rub off some of the starch-iodine complex, especially at the pressure points, and make the subsequent photographs less spectacular. It should be mentioned that this starch-iodine mixture washes off readily with soap and water and causes no inconvenience except for a temporary smarting of the scrotum at the time of application of the iodine. No cases of hypersensitivity to iodine were observed. Each group consisted of ten men and the tests performed are listed in Table II.

TABLE II

Sweat Tests Performed

Group	Date	Temperature	RH	Sweating**
I	2/5/45	70° F.	51%	Minimal
II	2/5/45	79° F.	86%	Minimal
I	2/6/45	85° F.	36%	Minimal
II	2/6/45	85° F.	75%	Moderate
I	2/7/45	97° F.	42%	Profuse
II	2/7/45	90° F.	62%	Profuse

* Burns of moderate erythema or greater were used in the calculations since it was considered that they represent significant H burns whereas readings of mild erythema may not always be due to H and their use would detract rather than add to the significance of the results.

** On body regions other than axillary and genital.

Part II - RESULTS.

A. Basic Tests with H Vapor.

(1) Introductory Remarks.

49. In view of the number of men involved in the tests described in this report, it is impractical to give a detailed description of each case history. Therefore, the data are presented in tabular form and the results are described in a generalized manner. Summarized data are presented in Table III in which are listed the basic tests performed and the average maximum intensities of reaction for the neck, axillae, scrotum, and the rest of the body. More detailed data are given in the following tables in the Appendix:

(1) In table VI are presented the maximum regional readings for individual subjects based on the numerical system described previously. Also included are the average, minimum, and maximum days required for the lesions to reach maximum average intensities for the different regions for each group of men. In severe burns, the days tabulated do not always give a concise impression of the maximum severity since, for example, a lesion might be recorded as a 5 (vesication, crusting, or ulceration) on the fourth day, but develop in size or depth for several days following. The method may also give an impression of greater severity than really existed; for example, a lesion may be recorded as a 3 on only one day and the erythema thereafter may fade to a 2 or a 1 by the next day. Such a lesion is certainly less severe than one which remains of 3 intensity for several days in succession. In spite of these minor occasional fallacies, the method usually leads to a fairly accurate estimate of the severity of skin damage.

(2) In Table VII are listed the number of men in each test showing maximum regional readings of a given intensity and includes the average regional intensities.

(3) In Table VIII are listed the damage indices for each area and the total damage indices for the various tests.

(4) In Table IX are listed the "Area Factor" times the number of men in each group showing moderate erythema or worse for each area and the average percentages of skin area showing moderate erythema or worse in each test.

(2) General Description.

50. Since the reactions to H vapor of the general body surface (rest of body), the neck, the axillae, and the scrotum (and penis), were quite different, the descriptive presentation of the results is facilitated by considering them separately.

TABLE III
Basic Tests Performed

Test No	Date	CT	Temp. °F.	RH %	H_2O mg/l	No. Men	Average Maximum Reaction Intensity: Neck	Axilla	Scr	Rest of body
1	3/28/44	50	90	65	22	6	0.3	0.0	0.0	0.1
2	7/25/44	50	90	65	22	5	1.2	0.6	0.2	0.5
3	3/30/44	100	90	65	22	6	1.2	0.3	1.2	0.7
4	7/25/44	100	90	65	22	5	1.6	1.8	0.8	0.9
5	1/25/45	100	100	35	16	6	1.5	0.2	1.3	0.6
6	1/25/45	100	100	67	30	6	1.5	0.0	0.3	0.6
7	4/ 4/44	150	90	65	22	10	2.0	0.2	0.3	0.7
8	7/26/44	150	90	65	22	6	3.0	3.0	2.2	2.1
9	11/20/44	200	70	53	10	7	1.0	1.4	0.4	0.3
10	1/23/45	200	80	46	12	6	1.7	0.5	1.5	0.5
11	1/23/45	200	80	86	22	5	1.6	0.4	0.0	0.4
12	4/11/44	200	90	65	22	10	2.2	1.3	2.1	1.2
13	7/27/44	200	90	65	22	6	4.0	2.8	3.2	2.4
14	1/27/45	200	100	66	30	4	4.0	2.8	4.8	2.7
15	4/17-22/44	250	90	65	22	15	2.4	2.0	3.2	1.6
16	7/28/44	250	90	65	22	6	4.2	3.2	3.7	2.8
17	11/28/44	300	70	60	11	6	1.7	2.8	2.0	0.7
18	1/24/45	300	80	85	21	4	3.0	2.3	0.0	1.2
19	2/28/45	300	85	36	10	8	1.5	2.3	*	0.6
20	2/28/45	300	85	77	22	8	2.8	2.3	*	1.8
21	3/10/45	300	90	37	13	7	3.0	3.0	*	1.8
22	4/24/44	300	90	65	22	5	**	2.4	*	2.2
23	11/28/44	300	90	65	22	6	3.3	3.0	*	2.4
24	3/22/45	300	90	65	22	5	3.4	3.0	*	2.9
25***	3/22/45	300	90	65	22	5	2.8	2.0	*	2.0
26	12/ 1/44	400	70	62	11	6	2.2	3.2	2.5	1.2
27	1/ 9/45	500	60	60	8	8	2.9	3.8	4.6	1.5
28	1/ 8/45	500	70	48	9	8	3.3	3.5	5.0	1.8
29	1/11/45	600	60	57	8	8	3.0	4.0	*	1.5
30	1/12/45	600	60	62	8	8	2.9	4.6	5.0	1.6
31	3/10/45	600	65	69	11	7	3.6	3.1	*	1.8
32	1/10/45	600	70	52	10	8	3.4	4.1	*	1.5
33	1/13/45	700	60	67	9	8	2.5	3.4	*	1.2

* Men wore CC-2 impregnated shorts
** Protective ointment applied to neck
*** Men precooled prior to chamber exposure

51. General body surface. From Table III, it is evident that at a given temperature, there was a progressive increase in severity of reaction with increasing CT. Reactions below 1.0 were mild; any average over 2.0 represented a fairly severe generalized erythema. Fairly severe reactions were sustained at CT 200 at 100° F. or at CT 200-300 (depending on season) at 90° F.; however, at 70° F., even at CT 500 or 600, the reactions had not attained this degree of generalized severity. It was not possible to determine at what CT a severe generalized erythema would result from exposure at the lower temperatures because of the severe reactions produced on the genitalia and axillae at CT 600. The extreme difference in severity of the burns on the general body surface was the most salient feature of the contrast in results obtained by exposures at high as compared with low temperatures. The difference in reaction at 90° F. as compared with 70° F. at comparable CTs is strikingly illustrated in Figures 2 and 3, Plate 2 and Figure 4, Plate 3.

52. Only limited data are available for considering the effects of relative humidity. The contrast between the results at high and low RH was marked at 85° F., CT 300; 36% RH resulted in an intensity of 0.6 as compared with 1.8 at 77% RH. Confirmatory pictures are shown in Figures 8-13, Plate 5. The same effect of RH was evident at 90° F. but was not as pronounced. It is interesting to note that at CT 300, the results obtained at a low RH at 85° F. were comparable to those obtained at 70° F.; and the results at high RH were comparable to those at 90° F., 37% RH. The difference between 46% and 86% RH at CT 200, 80° F. was not appreciable, nor was it appreciable at 35% and 67% RH at CT 100, 100° F.; however, the reactions were mild and the CT may have been too low to illustrate the effect of RH under these conditions. No tests were run in which RH was varied at the lower temperatures (60° - 70° F.).

53. Tests have been carried out in both the spring and in the summer at the following CTs: 50, 100, 150, 200, and 250 at 90° F., 65% RH. It is evident from the results listed in Table III that, at and above CT 150, there was an appreciably greater severity of skin damage sustained in summer tests as compared with those performed in the spring. The severe generalized erythemas sustained in the summer tests at CT 250 are illustrated in Figures 6 and 7, Plate 4.

54. The neck. Under the conditions of the tests reported in this series, a large part of the neck was exposed directly to the H vapor with no intervening clothing. In Table III, it can be seen that the trend in reaction with varying CT or temperature was identical with that of the general body surface, but the neck reactions were one unit (or more) of intensity greater than the average reactions on the rest of the body for a given set of conditions.

55. At 85° F., CT 300, high humidity (77% RH) caused much more severe neck reactions than low (36% RH), the average intensities being 2.8 and 1.5 respectively. Variations in humidity did not cause pronounced differences in the tests run at 80°, 90°, and 100° F.

56. Vesication was observed on the necks of only six men in the entire series. Four of these occurred in summer tests (Tests 13 and 16), one at CT 500, 70° F., 48% RH (Test 28) and one at CT 200, 100° F., 65% RH (Test 14).

57. Subsequent pigmentation of the neck was usually darker than for the other areas of the body (except the axillae), a fact which correlated well with the observation that neck reactions were generally more intense than those of the rest of the body.

58. As in the case of the general body surface, neck reactions were considerably more severe when tests at any given CT were performed in the summer than when performed in the spring (Table III).

59. Axillae. In contrast to the pronounced effect of temperature on reactions of the neck and general body surface, temperature of exposure did not exert a marked effect on the severity of burns of the axillae. Thus, at CT 300, comparable tests at 90° F. and 70° F., carried out on the same day (Tests 17 and 23) showed that the severity of axillary reactions was essentially the same in both tests. There was, however, in general, a difference in the appearance of axillary reactions observed in men exposed at high temperatures (90° F.) as compared with low (70° F). At the lower temperatures, the erythema began in the central hairy area and with increasing CT involved a larger area, finally including the axillary folds, upper medial arm, and upper lateral thorax (Figures 32, 33, Plate 9). At the higher temperatures, most often this central area was spared while the more peripheral axilla and folds showed intense reactions if the CT were sufficiently high (Figure 31, Plate 9). The above statements were generally true, but it must be added that the types of reactions which were usually observed after exposure to the higher temperatures have been also observed in some individuals at lower temperatures. Furthermore, it is of interest that at a low RH (37%) at CT 300, even at 90° F., the reactions in the axillae resembled those usually occurring at the lower temperatures.

60. There was a pronounced difference in the severity of the axillary reactions sustained in the summer tests as compared with the spring tests at corresponding CTs at 90° F., 65% RH (Tests 1 and 2, 3 and 4, 7 and 8, 12 and 13 and 15 and 16). In the summer tests, the intensities were an average of 1.5 units higher than in the spring tests (Table III).

61. Occasionally, although rarely, men have been observed who manifested no axillary reaction even though other members of the group received severe axillary burns (for example, Subject 504, Figure 5, Plate 3).

62. Vesication (i.e. actual bleb formation) has not been observed in the axillae of the subjects in this series of tests. Following the more severe burns (e.g. at CT 500-600), the skin underwent maceration followed by crusting and ulceration of the axillary folds (Figure 36, Plate 10). Elevation of the arm caused pain in such cases.

63. Intense pigmentation was conspicuous in axillary reactions (Figures 32 and 33, Plate 9). The men were not observed sufficiently long to determine how long the pigmentation persisted.

64. Scrotum and Penis. From the standpoint of casualty production from H vapor among men wearing gas masks, the scrotum and penis were the most vulnerable regions of the body. In order to minimize the number of such lesions in this series of tests, men wore protective shorts in most cases

when it was anticipated that the scrotum would be severely affected. This procedure has somewhat curtailed the data on the effects of CT, temperature, and RH on scrotal susceptibility to H vapor.

65. Since various degrees of scrotal erythema are difficult to read accurately and since crusted lesions are far more significant from a military point of view, only the latter type of injury will be discussed. With this in mind, it is evident from Tables VI and VII in the Appendix that there is considerable individual variation in the vulnerability of the scrotum to H vapor up to CT 400. At CT 200, if the tests at 90° F. and 100° F. are considered collectively (Tests 12, 13 and 14), it can be seen that six out of twenty men sustained crusted lesions. Similar lesions were observed in eight of twenty-one men exposed at CT 250, 90° F. 65% RH (Tests 15 and 16). Only one of ten men showed a crusted lesion from exposure at CT 300, 70° F., and 80° F. (Tests 17 and 18); but the rest of the men exposed to CT 300 at a higher temperature all wore CC-2 impregnated shorts so that it is not known if this CT would have caused a larger number of casualties at a higher temperature (e.g. 90° F.) of exposure. Crusted lesions occurred in two of six men exposed at CT 400 at 70° F.

66. In spite of a low temperature of exposure, twenty-three of twenty-four men exposed to CT 500 and 600 (Tests 27, 28 and 30) sustained crusted lesions. Because this group of cases is considered the most important, the pertinent data has been presented in Table IV.

67. The course of the lesions in these twenty-three cases showed some variation but, in general, twenty-four to forty-eight hours after exposure, marked scrotal erythema was present. Dry scaling appeared on about the third day (Figure 19, Plate 7, and Figure 25, Plate 8) on the dependent surface of the scrotum. This scaling was followed by oozing and crust formation. Crusted lesions were usually present by about the fourth or fifth day, gradually increased in severity to a maximum at about the eleventh to the sixteenth day and were healed by about the twenty-second day after exposure. Removal of the crusts revealed ulcers which were, in general, fairly shallow.

68. In none of the tests described in this report was vesication (that is, actual blob formation) observed on the scrotum or penis.

69. Nineteen of the twenty-four men listed in Table IV developed lesions of the penis and foreskin. These usually appeared later than the scrotal lesions (fifth to nineteenth days, average fourteenth), reached maximum severity about seventeenth to twentieth days and were healed by about the twenty-sixth day. These penile lesions most frequently involved the prepuce and the surface of the penis in contact with the scrotal lesions; however, a few cases were observed of independent lesions on the anterior surface of the body of the penis. Preputial edema was frequent, but in no case was severe enough to hinder micturition.

70. Illustrations of these penoscrotal lesions are presented in Plates 6, 7 and 8 of the Appendix.

71. No treatment, except confinement to bed, was used. The course of healing was uneventful, although slow, and no clinical symptoms of infections were observed. Although the lesions were painful on contact, pain was not a conspicuous feature while the men were at rest.

72. When healed, the scrotum presented a mottled appearance, being pale in the areas which had been ulcerated and deeply pigmented in the less severely injured areas (Figures 17 and 18, Plate 6). Scarring was only rarely observed since the lesions were usually superficial. (An exception to this generalization is shown in Figure 30, Plate 8.)

(3) Special Tests.

73. Effects of environmental temperature immediately prior to chamber exposure. (Tests 24 and 25, Table III, Page 13). All of the five men who were kept at a comfortable room temperature for two hours prior to exposure showed intense generalized erythema. Four of the men who had been precooled showed mild to moderate erythema while one at first showed an intense erythema; however, after eight days, the erythema of this man had begun to fade whereas that of the controls remained intense. The contrast in pigmentation at fourteen days was very marked (Figure 35, Plate 10). In view of the previously noted small effect of temperature of exposure on the severity of axillary burns, it is particularly noteworthy that, in this test, the severity of the axillary reaction of the controls was 1.0 units higher than that for the precooled group. This difference appears to be closely related to the differences found in axillary burns in the summer as compared with the spring series of tests. It is obvious that precooling resulted in much less severe reactions even when the men were exposed simultaneously to a very effective CT at 90° F., 95% RH.

TABLE IV

Crusted Lesions of Scrotum and Penis *

Test No. 27
500 CT
Temperature 60° F.
Relative Humidity 60%

	SCROTUM				PENIS			
Subject	Start	Maximum Severity		Healed	Start	Maximum Severity		Healed
494	4	4-17	Mild	21				
495	4	17-18	Mod	20	17	18	Mild	20
496	4	13-17	Sev	28	18	18-22	Mod	26
497	5	5	Mild	20				
498			NONE					
499	6	11-15	Mod	21	18	18-21	Mild	21
500	4	8-16	Mod	23				
501		10-19	Sev	24	19	21-23	Sev	30

* Figures represent number of days after chamber exposure.

TABLE IV (Continued)

Crusted Lesions of Scrotum and Penis *

Test No. 28
500 CT
Temperature 70° F.
Relative Humidity 48%

	SCROTUM				PENIS			
		Maximum				Maximum		
Subject	Start	Severity		Healed	Start	Severity		Healed
486	5	8-17	Sev	23	8	17-23	Sev	32
487	2	8-15	Sev	23	16	18	Sev	26
488	14	19	Mod	23	14	14-22	Mod	32
489	4	21	Mod	25		21	Sev	27
490	5	10-16	Mod	19	16	17-20	Sev	28
491	5	8-18	Sev	28	17	17-24	Sev	28
492	5	8-16	Sev	21	19	20-21	Mild	22
493	4	9	Mod	22	19	19-20	Mild	23

Test No. 30
600 CT
Temperature 60° F.
Relative Humidity 62%

		SCROTUM				PENIS		
		Maximum				Maximum		
Subject	Start	Severity		Healed	Start	Severity		Healed
518	6	14	Mod	20	6	14-17	Sev	27
519	4	10-15	Sev	19	6	15-19	Mod	25
520	4	5-14	Sev	16	6	7-13	Mod	16
521	4	12-15	Sev	24	10	13-21	Sev	27
522	4	11-15	Sev	19	5	16-20	Mod	26
523	5	15-16	Sev	28	17	19-20	Mild	27
524	5	12-16	Sev	21	14	17-21	Mod	27
525	5	16	Sev	20				

* Figures represent number of days after chamber exposure.

74. Use of aluminum chloride. The results of this test (Test 28), in which the left axillae of the men were treated with aluminum chloride prior to exposure to H vapor, are presented in Table V and typical cases are illustrated in Figures 37, 38 and 39, Plate 11. It is evident that pretreatment with aluminum chloride, in most cases, resulted, not only in less intense reactions to H vapor, but also in reactions involving a lesser area. Consideration of both area and intensity is essential to best appreciate the effect of aluminum chloride on the reactions.

TABLE V

Effect of Pretreatment of Axillae with Aluminum Chloride

(Test No. 28 - H at CT 500; 70° F., 48% RH)

Subject	Intensity		Area Involved	Picture in Appendix
	Right (Control)	Left (Treated)		
486	Erythema with edema Maceration Crusting	Moderate erythema	Much less on left	Fig. 37
487	Intense erythema	Intense erythema	No appreciable difference	
488	Moderate erythema	Mild erythema	Much less on left	
489	Erythema with edema Maceration Crusting	Intense erythema	Much less on left	Fig. 39
490	Erythema with edema	Erythema with edema	Slightly less on left	
491	Intense erythema	Mild erythema	Slightly less on left	
492	Erythema with edema	Intense erythema	Much less on left	Fig. 38
493	Intense erythema	Moderate erythema	Slightly less on left	

75. Use of lanolin. Application of lanolin immediately prior to entering the chamber to several areas of the skin of men exposed to H vapor at CT 500, 70° F., 48% RH (no generalized sweating), (Test 28), or at CT 300, 90° F., 65% RH (generalized sweating), (Test 24), neither increased nor decreased the intensity of reactions.

76. Artificial wetting of the skin. The right half of the body, covered by the dry skivvy shirt, showed no significant reaction except in the axillae of two of the six men. Conversely, on the left side, the skin subjacent to the wet skivvy shirt was obviously more severely affected in the axillae, axillary folds, upper medial arm, and lateral thorax, in which areas the men all sustained intense erythemas. The thorax on this side showed a very mild erythema which faded in a few days. It is probable that the wet shirt interfered with H vapor penetration to the thorax whereas the open end of the short-length skivvy shirt sleeve permitted ready access after it had passed through the dry outer denim shirt sleeve. That artificial wetting of the skin did enhance the reaction is well shown in Figure 34, Plate 10.

(4) Total Damage Index.

77. The corrected total damage indices given in Table VIII are presented graphically in Plate 14, in which total damage index is plotted against CT for the various tests performed. The indices, corrected for the area covered by the protective shorts, were used to permit comparison of a larger number of tests. It can be seen that for any given temperature, there is a progressive increase in total damage index with increase in CT. Higher temperatures of exposure result in a higher total damage index than lower ones at any given CT. It was found that correction of the data for the area covered by the protective shorts lowered the points very little and did not appreciably change the slope of the curves.

78. It may also be noted in Plate 14 that the indices for the summer series of tests at 90° F. are consistently higher than those for the spring series at the same temperature, a fact which correlates with the previously mentioned descriptive differences in paragraph 53.

79. In Plate 15, total damage index is plotted against temperature. At CT 200, there is relatively little change in the total damage index from 70° F. to 80° F., whereas from 80° F. to 100° F., there is a sharp rise. The curve for CT 300 parallels that for CT 200. Several points at 60° F. to 70° F. are included for CT 500 and CT 600 and can be seen to lie well above those for CTs 200 and 300. It may be inferred that even at these lower temperatures, severe generalized erythema may occur if the CT is sufficiently high.

80. In Plate 15, it may also be seen that there is a marked difference in the points for high and low humidity at CT 300 at 85° F. The point for the low humidity at CT 300 lies on the curve for CT 200. There is a similar difference for the high and low humidities at 90° F., but the effect is not as marked.

(5) Percentage of Exposed Area Affected.

81. In Plate 16, the percentage of exposed area which sustained a moderate erythema or worse is plotted as ordinate against CT as abscissa; and in Plate 17, the same ordinate is plotted against temperature. These curves are similar to those for the total damage indices (Plates 14 and 15). The sharp rise of the curves on Plate 17 above 80° F., showing a great increase in the area involved, is, indeed, spectacular and correlates very well with visual impressions.

B. Sweat Tests.

82. The results of the sweat tests are illustrated in Figures 40 - 51, Plates 12 and 13, and are summarized in Table II. An appreciable amount of sweating was evident in the axillae and genital regions of most of the men even at the lower temperatures. Even from this semi-quantitative test, it was evident that there was considerable individual variation in the amount and distribution of sweating. Sweating was minimal over the general body surface at 70° F., 51% RH, and 79° F., 86% RH, and profuse at 90° F., 62% RH, and 97° F., 42% RH. At 85° F., the effect of RH was marked. The men exposed at 36% RH showed minimal sweating whereas those at 75% RH showed

a moderate amount as is evident in the photographs. Thus, at this temperature, variation in RH had a marked effect on the amount of sweat secreted and on the areas involved as demonstrated by this method.

Part III - DISCUSSION.

A. Correlation of Skin Susceptibility to H Vapor with Sweating.

83. It has been repeatedly observed in reports by many investigators that sweating men (whether sweating is induced by high temperatures or exercise) are much more susceptible to the skin effects of H vapor than non-sweating men. No report has been observed, however, in which sweat tests have been performed under the same conditions as the H vapor exposures in an attempt to arrive at a more exact understanding of this fact.

84. The starch-iodine method of demonstrating sweating has been in common clinical use for many years. It offers an excellent simple way to determine whether or not an area is actively sweating. Insensible perspiration is not sufficient, apparently, to give a positive reaction. With regard to the absolute amount of sweat secreted in a given area, this method is, at best, semiquantitative. It must be emphasized that the intensity of color observed is influenced by the lateral spread of sweat after it leaves the pores. Theoretically, there is a small range in which the amount of sweat secreted would be proportional to the color intensity. However, in most cases in which sweating occurs, it is sufficiently profuse to maximally darken the area. The rate at which sweat evaporates from the skin surface probably modifies the results somewhat. Thus, at low humidities, the rapid evaporation of sweat might tend to give readings of lower intensity. In spite of its limitations, the method has proved very useful and correlates well with more quantitative studies by other workers in which water vapor was collected and weighed.

85. It is generally accepted that, below a dry bulb temperature of 85-87° F., most lightly clothed, resting men show active glandular sweat secretion only on the palms, soles, axillae, and genital regions. The main body surface, under these conditions, shows only a relatively small water vapor loss, presumably by direct evaporation through the skin (insensible perspiration). Above 85-87° F., most individuals show generalized active sweat secretion over the entire body surface. The temperature at which generalized sweating begins is lowered by exercise and by wearing heavy clothing. Winslow and Gagge found that this threshold was lower for exercising men in the summer than for exercising men in the winter (American Journal of Physiology 134: 664-681, 1941). This fact may be related to the difference in results of H vapor exposures in spring as compared with summer.

86. A good correlation between sweating and skin susceptibility to H vapor was observed. This was well demonstrated when men were exposed at CT 400 at 70° F., 62% RH and at CT 300 at 90° F., 65% RH. In the former case, intense erythema was confined to the axillae, whereas the rest of the skin showed only minimal effects (men wore protective shorts). In the latter case, the men showed intense generalized erythema, even though the CT of exposure was actually lower (Figures 2 and 3, Plate 2). The excellent correlation of these results with the extent of sweat-

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ing of the areas involved is seen readily by comparison with the illustrations of the sweat tests. In Figures 40 and 41, Plate 12, it is apparent that at 70° F., 56% RH, the men were sweating only in the axillae and genital regions, and Figures 44 and 45, Plate 12 show that generalized sweating occurred at 90° F., 65% RH.

87. Since 85° F. is approximately the temperature above which resting men begin to show generalized sweating, it was felt that this would be the optimum temperature at which to study the influence of relative humidity on the active secretion of sweat and on the effects of exposure to H vapor. Sweat tests at 85° F., 36% RH, gave results similar to those at 70° F., 51% RH, namely, sweating confined to the axillae and genital regions (Figures 46 to 49, Plate 13); whereas at 85° F., 75% RH, the men showed moderate generalized sweating which approached that at 90° F., 62% RH (Figures 50 and 51, Plate 13). Similarly, tests with H vapor at CT 300, 85° F., 36% and 77% RH, showed an appreciably greater intensity of erythema at the higher RH (Figures 8 to 13, Plate 5). Since the sweating threshold varies from man to man, it can be expected that at 85° F., there would be considerable individual variation in sweating. Nevertheless, it is evident that elevation of humidity at this temperature, which does increase the wetness of the skin, also increases the intensity of reactions to H vapor. It is of interest that the results with the lower RH at 85° F. were similar to those reactions at a low temperature (70° F.), whereas those at the higher RH were similar to those at 90° F.

88. Definite as is the effect of sweating in increasing the susceptibility of the skin to H vapor, it may be modified by differences in regional susceptibility. For example, the palms and soles, which are sweating at the lower temperatures employed and were certainly sweating at the higher temperatures, are very resistant to H vapor. The soles were probably protected by the shoes. The skin of the unprotected palms is in itself more resistant than the skin of the rest of the body. Conversely, starch-iodine tests on the genital region reveal few or no sweat pores on the scrotum itself, although the adjacent inguinal, pubic, and perineal skin is richly provided with them; and yet, the scrotal skin is the most susceptible skin to H vapor. It is felt that these exceptions in no way vitiate the thesis on the effect of sweating on the susceptibility to H vapor of the skin of the rest of the body surface but merely emphasize the importance of the primary differences in regional susceptibility.

B. The "Radiator" Effect.

89. It was mentioned in NRL Report P-2219 that "in general, exposures in the large chamber produce reactions which are approximately twice as severe as those produced in the 'arm chamber' at the same CT". In "arm chamber" exposures only the forearm was exposed at 90° F., 65% RH whereas the remainder of the body is at 70-80° F., 20-30% RH. In large chamber exposures the whole body is exposed to 90° F., 65% RH. Experiments in which the arm was exposed at 90° F., 65% RH in the arm chamber

and the room was also maintained at 90° F., 65% RH, yielded results which approached those of the large chamber in severity. At this time it was stated that the rest of the body "is capable of functioning as a 'radiator' and thus succeeds in altering the reactivity of the exposed surfaces and reduces the severity of the reaction" when the body is at a comfortable room temperature (70-80° F.).

90. From the present series of tests it is evident that the "radiator" effect is due to the fact that at 90° F., 65% RH, generalized sweating occurs, whereas at 70-80° F. it probably does not (or is mild). Thus, in the former case, the exposed forearms would be sweating, but not in the latter. Exposing the whole body at 90° F., 65% RH causes generalized sweating and, under this condition, the forearm in the arm chamber reacts more as it does in the large chamber (at 90° F. 65% RH).

C. Casualty Production.

91. The many and often ambiguous connotations of the word "casualty" make a discussion of "casualty production" difficult. For the purpose of this report, a man who is unable to carry on his complete duties as a result of exposure to a chemical warfare agent, would be a "casualty". In general, casualties from H vapor are produced in two ways which may be observed independently or in combination:

(1) Systemic Effects
(2) Local Effects.

92. Systemic Effects. Under the conditions of the tests included in this report, none of the men showed any systemic effects. No malaise, nausea, vomiting, headache or shock were observed even in the men with severe generalized erythema. However, it must be emphasized that, for the most part, the men were living under temperate conditions before and after exposure and were leading a rather sedentary existence. The Australian investigators, on the other hand, in C.D. (Australia), Report No. 55, dated 18 October 1944, have observed a relatively large number of men showing systemic effects after exposure to H vapor at CTs of 50 to 750. They emphasize that their tests were performed under tropical conditions and regard climate as an important factor.

93. Since many of the symptoms which are described in the literature as systemic effects of H vapor may also be observed following sunburn, thermal burns or heat exhaustion, and since many of these symptoms may have a strong psychic or suggestive basis, their ascription to H vapor is often questionable.

94. Local Effects. In this series of tests, the local reactions most likely to be casualty producing were observed in the axillae and on the genitalia. Even the worst axillary reactions could hardly be called "casualty producing". Pain on elevation of the arm was present in the more severe cases, but was never of such a degree as to hinder a man significantly under the stress of combat. This pain might be sufficient to lower morale during routine activities.

95. Many of the penoscrotal reactions observed in this series of tests were severe, and while not rendering a man unable to take part in emergency defensive combat, would definitely have hindered offensive operations. Although these penoscrotal lesions reached a casualty producing degree only after several days, it must be recognized that the men were kept at bed rest. Had they been forced to march and carry on regular military routine, it is likely that the lesions would have developed sooner and become much more severe.

96. Some men suffered from generalized itching, especially in hot weather, but this was not of casualty producing magnitude.

SUMMARY AND CONCLUSIONS

1. Basic tests, that is, tests with H vapor on men wearing ordinary clothing and unprotected except for masks and, in some cases, protective shorts, have been performed under the following exposure conditions:

Time of Year	Temp. ° F.	Relative Humidity (%)	CT
Jan. 1945	100	35 and 65	100
Jan. 1945	100	65	200
Mar. - Apr. 1944	90	65	50 to 250 (300*)
July 1944	90	65	50 to 250
Nov. 1944	90	65	(300*)
Feb. 1945	85	35 and 75	(300*)
Jan. 1945	80	45 and 85	200
Jan. 1945	80	85	300
Nov. 1944-Jan. 1945	70	55	200 to 500 (600*)
Jan. 1945	60	55	500 to 600 (600-700*)

* CC-2 impregnated shorts worn during exposure to H vapor

2. The system of taking readings and recording data in use at this Laboratory is described. It was found that when the temperature of exposure was varied, the method of taking the maximum severity of skin reaction, regardless of what body region was involved, as the index of reaction to that CT, was no longer applicable. The data from these tests has been evaluated and discussed in several different ways: (1) description; (2) total damage index, in which regional intensity readings are weighted on the basis of the amount of skin area involved; and (3) the percentage of skin area exposed showing moderate erythema or worse.

3. The severity, type and location of burns due to H vapor at a given CT are influenced markedly by the temperature of exposure. At low temperatures (80° F. or below), the burns are localized and are limited mainly to the axillae and genitalia. At high temperatures (90° F. or above), the burns are generalized and cover most of the body. The differences in reactions at high and low temperatures, as regards the area of skin involved, is nicely depicted by the total damage indices and percentages of skin area showing moderate erythema or worse.

4. From H vapor exposures at 90° F. and CT 250 and 100° F and CT 200, intense generalized erythema was observed over most of the body, with scrotal reactions somewhat more severe. At 70° F. and CT 500 and 60° F. and 600 CT, only moderate erythema was produced on most of the body, but maceration and mild crusting were produced in the axillae, and severe ulcerated and crusted lesions occurred on the genitalia.

5. In contrast to the pronounced effect of temperature on reactions of the neck and general body surface, temperature of exposure did not exert a marked effect on the severity of burns of the axillae. Temperature did, however, influence the configuration of axillary burns. Burns occurring at low temperatures involved primarily the central axilla; those at high temperatures usually spared the central axilla and affected the more peripheral axillary folds.

6. The effect of the relative humidity during exposure on the vesicant power of H vapor on clothed, resting men was pronounced at 85° F. which is near the average temperature threshold for generalized sweating. The same effect of RH was evident at 90° F. but was not as pronounced.

7. Tests at CTs 150, 200 and 250 at 90° F., 65% RH, resulted in appreciably more severe reactions when carried out in summer than when performed in the spring.

8. Exposure to H vapor at CTs above 500, even under temperate conditions of exposure (60-70° F.), and under temperate living conditions produced crusted and ulcerated lesions of the scrotum and penis in 23 out of 24 unprotected men. These crusted lesions appeared at three (3) to five(5) days and required three (3) to four (4) weeks to heal in men at bed rest. Crusted lesions of the penis were less frequent and were slower to appear, the average being 14 days after exposure. CC-2 impregnated shorts completely protected against genital injuries.

9. Precooling men prior to chamber exposure markedly diminished the severity of the skin reactions from H vapor. This may be one of the factors causing less severe burns in spring tests than in summer tests.

10. Suppression of axillary sweating by pretreatment of the axilla with aluminum chloride resulted, in most cases, in not only less intense reactions to H vapor, but also in reactions involving a lesser area.

11. Application of lanolin to the skin, shortly before chamber exposure to effective CTs of H vapor, neither increased nor decreased the intensity of the reactions of sweating or non-sweating men.

12. Wetting of the skin with artificial sweat resulted in increased severity of reaction to H vapor.

13. Tests (starch-iodine method) carried out to determine sweating of the different body areas under the same conditions as the H vapor exposure, showed a close correlation between the extent of sweating and the severity of H burns produced on the same areas. At low temperatures (70° F.), active sweat secretion was confined to the palms, soles, axillae, and genital region; with the exception of the palms and soles, these were the areas most affected by H vapor. At high temperatures (90° F.), both sweating and H vapor burns were generalized. The threshold temperature for generalized sweating and susceptibility to H vapor for most of the body occurred between 80° and 90° F. for lightly clothed, resting men.

RECOMMENDATIONS

None

ACKNOWLEDGMENTS

Human Volunteers. This program could not have been carried out without the men who bravely volunteered to participate in the tests knowing the personal inconvenience which might result. For service definitely beyond the call of duty they are deserving of the greatest praise. This Laboratory wishes to express great appreciation for the cooperation of the Commandant of the U. S. Naval Training Center, Bainbridge, Maryland in permitting volunteer personnel to take part in these tests.

Color Prints. Kodachrome transparencies were submitted to the Photoscience Laboratory, Naval Air Station, Anacostia, D. C. for reproduction. The expert services and whole-hearted cooperation of that Laboratory has made possible the presentation of results which could have been effectively shown in no other manner.

Chamber Operation. R. E. Cunningham was responsible for establishing and maintaining the chamber conditions used in the various tests.

Medical Unit. The following personnel actively participated in performing the tests:

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F. J. Folker,	C.Y.
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B. Winter,	PhM2c
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C. F. Adams,	Cox

APPENDIX A

TABLE VI

Maximum Regional Erythema for Individual Subjects

Test No. 1 - 3/28/44
CT = 54
90° F. 69% RH

Man No.	1	2	3	4	5	6	Days to Max. Severity Av.	Min.	Max.
abeck									
apet									
lmack		1			1		1	1	1
elev									
ash									
earm									
cf									
fa									
hf	1				1				
maf									
ax									
lth									
rth	1				1				
abd									
il									
inc									
pen									
scr									
athl									
kn									
aleg									
peur									
pneck									
pf									
rel									
jerm		1			2				
clt									
cf									
sc			1		2				
dtr		1			1				
lumb									
bc									
pkni									
pop									
pleg									

Test No. 2 - 7/25/44
CT = 49.5
90° F. 65% RH

Man No.	1	2	3	4	5	Days to Max. Severity Av.	Min.	Max.
abeck								
apet								
lmack								
elev								
ash								
earm								
cf								
fa								
hf								
maf								
ax								
lth								
rth								
abd								
il								
inc								
pen								
scr								
athl								
kn								
aleg								
peur								
pneck								
pf								
rel								
jerm								
clt								
cf								
sc								
dtr								
lumb								
bc								
pkni								
pop								
pleg								

Test No. 3 - 3/30/44
CT = 99
90° F. 65% RH

Man No.	1	2	3	4	5	6	Days to Max. Severity Av.	Min.	Max.
abeck									
apet									
lmack									
elev									
ash									
earm									
cf									
fa									
hf									
maf									
ax									
lth									
rth									
abd									
il									
inc									
pen									
scr									
athl									
kn									
aleg									
peur									
pneck									
pf									
rel									
jerm									
clt									
cf									
sc									
dtr									
lumb									
bc									
pkni									
pop									
pleg									

Test No. 4 - 7/25/44
CT = 97
90° F. 65% RH

Man No.	1	2	3	Days to Max. Severity Av.	Min.	Max.
abeck						
apet						
lmack						
elev						
ash						
earm						
cf						
fa						
hf						
maf						
ax						
lth						
rth						
abd						
il						
inc						
pen						
scr						
athl						
kn						
aleg						
peur						
pneck						
pf						
rel						
jerm						
clt						
cf						
sc						
dtr						
lumb						
bc						
pkni						
pop						
pleg						

Test No. 5 - 1/25/45
CT = 102
99.5° F. 3% RH

Man No.	1	2	3	4	5	6	Days to Max. Severity Av.	Min.	Max.
abeck									
apet									
lmack									
elev									
ash									
earm									
cf									
fa									
hf									
maf									
ax									
lth									
rth									
abd									
il									
inc									
pen									
scr									
athl									
kn									
aleg									
peur									
pneck									
pf									
rel									
jerm									
clt									
cf									
sc									
dtr									
lumb									
bc									
pkni									
pop									
pleg									

Test No. 6 - 1/25/45
CT = 99
99° F. 67% RH

Man No.	1	2	3	4	5	6	Days to Max. Severity Av.	Min.	Max.
abeck									
apet									
lmack									
elev									
ash									
earm									
cf									
fa									
hf									
maf									
ax									
lth									
rth									
abd									
il									
inc									
pen									
scr									
athl									
kn									
aleg									
peur									
pneck									
pf									
rel									
jerm									
clt									
cf									
sc									
dtr									
lumb									
bc									
pkni									
pop									
pleg									

Test No. 7 - 4/4/44
CT = 150
90° F. 69% RH

Man No.	1	2	3	4	5	6	7	8	9	10	Days to Max. Severity Av.	Min.	Max.
abeck													
apet													
lmack													
elev													
ash													
earm													
cf													
fa													
hf													
maf													
ax													
lth													
rth													
abd													
il													
inc													
pen													
scr													
athl													
kn													
aleg													
peur													
pneck													
pf													
rel													
jerm													
clt													
cf													
sc													
dtr													
lumb													
bc													
pkni													
pop													
pleg													

Test No. 8 - 7/26/44
CT = 150
90° F. 69% RH

Man No.	1	2	3	4	5	6	Days to Max. Severity Av.	Min.	Max.
abeck									
apet									
lmack									
elev									
ash									
earm									
cf									
fa									
hf									
maf									
ax									
lth									
rth									
abd									
il									
inc									
pen									
scr									
athl									
kn									
aleg									
peur									
pneck									
pf									
rel									
jerm									
clt									
cf									
sc									
dtr									
lumb									
bc									
pkni									
pop									
pleg									

Test No. 9 - 11/20/44
CT = 201
72° F. 53% RH

Man No.	1	2	3	4	5	6	7	Days to Max. Severity Av.	Min.	Max.
abeck										
apet										
lmack										
elev										
ash										
earm										
cf										
fa										
hf										
maf										
ax										
lth										
rth										
abd										
il										
inc										
pen										
scr										
athl										
kn										
aleg										
peur										
pneck										
pf										
rel										
jerm										
clt										
cf										
sc										
dtr										
lumb										
bc										
pkni										
pop										
pleg										

Test No. 10 - 1/23/45
CT = 198
79.5° F. 46% RH

Man No.	1	2	3	4	5	6	Days to Max. Severity Av.	Min.	Max.
abeck									
apet									
lmack									
elev									
ash									
earm									
cf									
fa									
hf									
maf									
ax									
lth									
rth									
abd									
il									
inc									
pen									
scr									
athl									
kn									
aleg									
peur									
pneck									
pf									
rel									
jerm									
clt									
cf									
sc									
dtr									
lumb									
bc									
pkni									
pop									
pleg									

Test No. 11 - 1/23/45
CT = 199
80° F. 66% RH

Man No.	1	2	3	4	5	Days to Max. Severity Av.	Min.	Max.
abeck								
apet								
lmack								
elev								
ash								
earm								
cf								
fa								
hf								
maf								
ax								
lth								
rth								
abd								
il								
inc								
pen								
scr								
athl								
kn								
aleg								
peur								
pneck								
pf								
rel								
jerm								
clt								
cf								
sc								
dtr								
lumb								
bc								
pkni								
pop								
pleg								

Test No. 12 - 4/11/44
CT = 199
90° F. 69% RH

Man No.	1	2	3	4	5	6	7	8	9	10	Days to Max. Severity Av.	Min.	Max.
abeck													
apet													
lmack													
elev													
ash													
earm													
cf													
fa													
hf													
maf													
ax													
lth													
rth													
abd													
il													
inc													
pen													
scr													
athl													
kn													
aleg													
peur													
pneck													
pf													
rel													
jerm													
clt													
cf													
sc													
dtr													
lumb													
bc													
pkni													
pop													
pleg													

TABLE VI (Con't.)

Test No. 13 7/27/44 — CT = 200, 90° F. 65% RH — Days to Max. Severity

Man No.	1 2 3 4 5 6	Av.	Min.	Max.
ameck	3 5 3 4 3 4	5	4	6
apst	5	6		
lneck				
elav				
ash	3 3 4 2 2	4	3	5
earm	3 3 3 2 3	4	2	6
ef	3 3 3 3 3 3	4	2	5
fa	3 3 5 2 3 3	4	2	5
wr	5 1 3	5	4	[illegible]
maf	3 3	5	5	5
ax	3 5 3 5 3	5	5	7
lth	3 3 3 2	4	2	5
vth	3 5 3 1 3 3	4	1	6
abd	3 3 3 3 3 3	4	2	6
il				
ing				
pen	2	5		
ecr	5 5 2 2 2 3	5	4	7
athi	1 2 1 2 1	3	2	5
kn	1 2 2 1 2 1	3	1	6
aleg	1 1 2 1	3	2	4
paur				
pneck	3 3 3 4 3 4	4	2	6
paf	2	3		
pah	5 3 2 2	4	3	6
parm	3 3 3 2 3	4	2	6
elb	2	1		
C7				
sc	3 3 3 3 3 4	4	2	6
dth	5 3 3 3 3 4	5	4	7
lumb	1 3	3	1	5
bt	3 2 3 2 2 1	4	2	4
pthi	1 2 8 1	3	2	4
pop	1 2 2 1	6	[illegible]	7
pleg	1 1 2 1 1	4	2	7

Test No. 14 1/27/45 — CT = 199, 99° F. 66% RH — Days to Max. Severity

Man No.	1 2 3 4	Av.	Min.	Max.
	4 3 4 4	4	3	5
	3 3 4 4	4	1	5
	4 3 4 4	4	3	5
	4 3 4 4	4	4	5
	3 1 3 3	4	2	5
	3 3 3 3	4	4	5
	3 3 3 4	3	1	5
	2 3 3 3	3	1	6
	3 2 3 3	2	1	4
	2 2 3 3	4	3	6
	2 3 2	5	4	6
	3 3 3 2	5	4	5
	3 1 3 2	4	2	5
	3 1 3 3	5	4	6
	3	4		
	5 5 4 5	12	9	13
	1 3 3 3	3	1	4
	2 3 3 3	3	1	4
	1 1 3 1	3	1	4
	4 3 3 3	2	1	5
	2 3 3 3	4	1	5
	3 3 3 3	3	1	4
	2 2 3 3	3	1	5
	2 2 3 2	4	1	6
	3 3 3 3	2	1	3
	3 3 3 3	3	3	4
	3 2 3 3	3	1	4
	1 3 3	3	1	5
	2 2 3 3	3	1	4
	1 3 3 3	3	1	4
	1 3 3 2	3	1	5
	1 1 2 2	4	1	5

Test No. 15 4/17 - 4/22/44 — CT = 290, 90° F. 65% RH — Days to Max. Severity

Man No.	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15	Av.	Min.	Max.
	2 3 2 2 2 2 1 2 2 3 2 3 3 3 3		1	3
	2 3 2 2 2 2 1 2 2 3 3 3 3 3 3		1	3
	3	3		
	1 2 2 1 1 2 1 2 2 2 3 2 2 3		1	5
	1 2 1 2 1 1 2 2 2 3 3 2 3		1	5
	2 3 1 2 2 2 2 1 2 2 1 4 4 2 4		1	9
	3 2 1 1 1 1 2 2 2 3		1	4
	2 2 1 1 2 1 2 1 2 2 1 2 3 1 3	2	1	4
	2 2 2 2 3 3		1	5
	2 2 2 2 2 2 2 5 5 3		1	9
	2 2 2 1 2 2 3 3 2 2	2	4	
	1 2 2 1 1 2 2 2 2 3 3 1 3		1	6
	1 1 2 5 3 2 3	4	1	8
	2 3	5	3	7
	1 2 1 1 1 1 2 1 2 3 2 2 2		1	6
	2 1 2 5 5 2 5 5 5 3 1 2 5 2 3	2	1	9
	1 3 2 1 1 1 1 1 2 1 2 2 1 2		3	8
	1 1 2 1 3 2			
	1 3 2 1 1 1 1 1 1 2 1 2	3	1	8
	2 3 2 2 2 2 1 2 2 2 2 3 3 3 3		1	3
	1 1 2 1 2 3 3		1	9
	1 2 2 1 1 2 1 2 2 2 3 2 2 3		1	5
	1 2 1 1 1 1 2 2 2 3 3 2 3		1	5
	2	1		
	2 2 2 2 1 2 3 3 3		1	5
	2 2 2 2 2 1 1 3 2 2 2 3 3 3 3		1	5
	1 1 2 2 3 2	3	1	4
	3 1 1 2 1 2 3 4 1 3		1	9
	1 5 2 1 1 1 1 1 2 1 2 2 1 3		1	9
	1 2 2 2 2 1 2	4	1	9
	1 5 2 1 1 1 1 1 1 2 2 1 2	3	1	8

Test No. 16 7/28/44 — CT = 249, 90° F. RH 65% — Days to Max. Severity

Man No.	1 2 3 4 5 6	Av.	Min.	Max.
	5 3 4 4 4 4	4	1	7
	5 5	6	5	7
	5 3 4 3 5	6	3	7
	2 5 5 5	5	1	7
	3 3 3 4 4 5	4	1	7
	3 4 3	3	1	5
	2 5 5	4	1	6
	3 3 3	4	1	7
	3 3 3 3 3 4	6	3	17
	3 3 4 3 3	5	3	7
	3 3 4 4 3 3	3	1	5
	5 3 1 4 3 3	4	1	7
	3 3 3 3	6	6	7
	3 3 2 3	5	3	7
	2 3 5 5 4 3	4	3	6
	2 3 3	3	1	5
	2 3 3 2	2	1	4
	2 1 3 3	4	5	5
	3 3 4 4 4 5	3	1	7
	1	2		
	3 3 4 3 3	5	3	7
	2 3 3 5	4	1	7
	3 3 2 3 3 3	4	3	7
	3 3 2 3 3 3	4	3	7
	3	7		
	3 3 2 3 2 3	3	1	7
	2 3 3	3	1	5
	2 1 2 3 3 3	4	1	5
	2 1 3 3	4	3	5

Test No. 17 - 11/26/44 — CT = 299, 71° F. 60% RH — Days to Max. Severity

Man No.	1 2 3 4 5 6	Av.	Min.	Max.
ameck	1 1 2 2 2 2	3	1	6
apst	1 1 1 2 2 2	2	1	5
lneck				
elav				
ash	1 1 1	4	2	5
earm				
ef	1 1 1 1 1 1	2	1	4
fa	1 1	3	2	3
wr				
maf				
ax	3 2 3 3 3 3	3	1	4
lth	2	5	5	5
vth	2 1	6	6	6
abd				
il				
ing	3	4		
pen	1 2	4	2	5
ecr	3 1 5 2 1	3	1	8
athi	2 2 2	3	2	4
kn	1 2 2 1 2	3	2	6
aleg				
paur				
pneck	1 1 2 1 2 2	2	1	5
paf	1 1	1	1	1
pah	1 1 1 1 2 1	1	1	2
parm	1 1 1 1	3	1	6
elb				
C7				
sc	1 1 1 1 1 1	2	1	[illegible]
dth	1 1 1 1 1 1	2	1	4
lumb				
bt	1	6	6	6
pthi	2 1 1	2	1	4
pop	1 2 2 1 1 2	4	2	4
pleg	2 2	4	4	4

Test No. 18 - 1/24/45 — CT = 301, 80° F. 85% RH — Days to Max. Severity

Man No.	1 2 3 4	Av.	Min.	Max.
	3 3 3 3	4	3	4
	3 2 2 2	4	3	4
	3 3 3 3	4	3	4
	2 2 2 2	4	3	5
	2 3	5	4	5
	2 1	4	2	5
	3 1 3 3	4	3	5
	1 1	1	1	1
	1 2	3	2	4
	2	5		
	2 3 2 2	5	4	5
	1 2 2 1		1	5
	1 2 1	3	1	4
	1 2	5	5	5
	2	4		
	1 1 1	2	1	4
	1 1 1	1	1	1
	1 1	1	1	1
	3 3 3 3	4	3	4
	2	5		
	1 1 2 2	3	3	4
	1 1 1	2	1	5
	1	2		
	1 1 2 2	3	3	4
	1 1 2 2	3	3	4
	1 1 2 2	3	3	4
	1 1 2	3	1	5
	1 2 2	2	1	4
	1 1	1	1	1
	1 1	1	1	1
	1 1	1	1	1

Test No. 19* - 2/26/45 — CT = 301, [illegible] F. 94% RH — Days to Max. Severity

Man No.	1 2 3 4 5 6 7 8	Av.	Min.	Max.
	3 1 1 1 1 1 1 1	3	1	6
	2 1 1 1	2	1	4
	3 1 1 1 1 1 1 1	3	1	6
	2 1	3	1	4
	1 1	4	2	6
	1	4		
	1 1 1 1 1 1	3	1	6
	1	6	6	6
	1 1	4	1	6
	3 [illegible] 2 3 [illegible] 2 1 1	4	2	7
	2	3		
	1 1	3	1	5
	1 1	2	1	5
	2	6		
	2 2 1	3	1	4
	1 2 1 1 1	2	1	6
	1 2 1 1 1 1 1	2	1	6
	1 1 1 1	5	2	7
	3 2 1 1 2 1 1	2	1	4
	2 3 1 1 1	2	1	3
	1 2	3	3	3
	2 1 1	3	2	4
	2 2 1 1 1	4	1	7
	2 2 2 1 1 1	2	1	4
	2 2 2 1 1 1	2	1	3
	1	2		
	1 1 1 1 1 1 1	2	1	4
	1 2 1 1 1	4	1	6
	1 2 1 1 1	3	1	6
	1 2 1 1 1	4	1	5

Test No. 20* - 2/26/45 — CT = 299, 84.5° F. 77% RH — Days to Max. Severity

Man No.	1 2 3 4 5 6 7 8	Av.	Min.	Max.
	3 2 1 3 3 3 3 3	4	3	6
	2 1 2 3 3 2 5	3	3	6
	3 2 1 3 3 3 3 3	4	3	6
	3 1 2 3 3 2 3	4	1	6
	1 1 2 3 1	4	1	6
	1 1 2 3 1	3	1	6
	2 2 1 2 3 5 5 3	4	1	6
	1 1 1 3 1 1	3	1	6
	1 3 1 2	3	1	6
	1 1 2 2 3 1	4	3	5
	3 1 3 2 2 2	4	2	6
	2 1 1 2 3 1 2 1	3	1	5
	1 1 1 3 3 1 1 1	3	1	6
	1 1 1 3 3 1 1	4	1	6
	2	1		
	2 1 1 2 3 2 3 2	3	1	5
	2 1 1 2 3 2 3 2	3	1	5
	1 1 2 3 3 2	5	4	7
	3 2 2 3 3 3 2 3	4	1	6
	2 1 1 3 3 2 3 2	3	1	6
	2 1 2 3 3 2 2 3	3	1	6
	2 1	3	1	4
	1 2 3 1	5	1	7
	2 1 2 3 3 2 2 3	4	1	6
	2 1 2 3 3 2 3 3	3	1	6
	2 1 2 3 3 2 2 3	3	1	7
	2 1 3 3	5	1	7
	2 1 1 2 1 1 2	2	1	4
	2 1 1 1 2 2 3 2	3	1	6
	2 1 1 1 2 2 3 2	3	1	6
	1 1 1 1 2 2 3 2	4	2	6

Test No. 21* - 3/13/45 — CT = 278, 90° F. 37% RH — Days to Max. Severity

Man No.	1 2 3 4 5 6 7	Av.	Min.	Max.
ameck	1 4 3 3 4 2 2	2	1	3
apst	1 4 3 3 4 2 [illegible]	2	1	3
lneck	1 4 3 3 4 2 2	2	1	3
elav	3 3 3 3 2	4	3	7
ash	1 1 2 1	3	1	4
earm	1 3 3	4	1	6
ef	1 2 2 3 3 1 1	2	1	4
fa	1 2	2	1	2
wr	1 2 2 2 3 1 2	3	1	5
maf	3 3 3 3	3	[illegible]	4
ax	3 3 5 3 3 9 3	3	1	5
lth	1 [illegible] 3 [illegible] 1	[illegible]	1	4
vth	1 1 3 3 3 1 1	2	1	4
abd	[illegible] 1 3 3 [illegible]	[illegible]	1	4
il	1	2		
ing				
pen				
ecr				
athi	1 2 2 1 [illegible] 1 1	2	1	5
kn	1 2 2 1 2 1 1	2	1	5
aleg	1 1 2 1 2 1 1	[illegible]	1	5
paur				
pneck	2 3 3 4 2 3	4	1	7
paf	3 3 3 3 1 2	2	1	5
pah	[illegible]	[illegible]	[illegible]	[illegible]
parm	2 1 2 1	3	1	5
elb	1 2 2 2 1	3	1	6
C7	1 3 3 4 1 2	3	1	7
sc	1 2 2 3 3 1 2	3	1	6
dth	1 2 3 3 3 1 2	[illegible]	[illegible]	5
lumb	2 3 3 3 [illegible]	[illegible]	[illegible]	[illegible]
bt	2	3		7
pthi	1 1 1 1 2 1 1	2	1	3
pop	1 1 1 1 2 1 1	1	1	2
pleg	1 1 1 1 2 1 1	3	1	[illegible]

Test No. 22* - 4/24/44 — CT = 279, 90° F. 65% RH — Days to Max. Severity

Man No.	1 2 3 4 5	Av.	Min.	Max.
	2 **			7
	2 **	3		
	3 2 3 1 [illegible]	3	1	5
	3 3 3 1 3	4	1	6
	3 3 3 4	5	2	7
	2 3	2	2	2
	1 2 1 1	3	2	5
	3 3	[illegible]	[illegible]	5
	[illegible] 3	5	5	5
	3 [illegible] 3	[illegible]	3	[illegible]
	3 3 3 1 2	5	3	6
	3 3 1 [illegible]	5	3	6
	1	2		
	1	5		
	1 2 1 1	[illegible]	1	6
	2 1 3 2	4	2	5
	2 1 3 2	5	2	7
	2 2 3 2	4	[illegible]	5
	** 3 3	4	3	[illegible]
	[illegible] 3 [illegible]	[illegible]	[illegible]	5
	3 3 3 1 3	4	2	5
	2 4 2	5	2	7
	3			7
	3 3 3 1 2	3	1	6
	3 3 4 3	4	2	7
	2 [illegible] 2	4	2	5
	2 2 [illegible]	3	2	4
	[illegible]	4	4	5

Test No. 23* - 11/[illegible]/44 — CT = 301, 90° F. 65% RH — Days to Max. Severity

Man No.	1 2 3 4 5 6	Av.	Min.	Max.
	4 [illegible] 4 3 3 3	2	1	5
	[illegible] 3 [illegible] 2 2	1	1	2
	3 3 3 2 3 2	3	2	4
	3 3 3 2	2	2	2
	3 3 4 3 3 3	3	1	4
	3 3	2	1	2
	3 1	5	3	6
	[illegible] 3 2	[illegible]	[illegible]	4
	3 3 [illegible] 3 3	2	2	4
	3 3 3 2 3 3	4	2	5
	3 3 3 2 3 2	[illegible]	[illegible]	[illegible]
	3 3	4	3	[illegible]
	3 3 3 2 2 2	5	2	7
	5 3 3 2 [illegible]	5	2	7
	4 3 4 3 3 3	2	1	5
	[illegible] 3 3	2	[illegible]	3
	3 3 3 3 [illegible] 3	2	1	5
	3 3 3 3	2	2	3
	3 3 3 3 3 3	2	1	5
	3 3 3 3 3 3	2	1	5
	3 3 [illegible] 3 3 [illegible]	[illegible]	1	[illegible]
	3 2 3 2 2	4	1	7
	3 2 3 1 1 2	3	1	6
	[illegible]	2		

Test No. 24* - [illegible] — CT = 278, 90° F. 65% RH — Days to Max. Severity

Man No.	1 2 3 4 5	Av.	Min.	Max.
	3 3 3 4 4	1	1	1
	3 3 3 4 4	1	1	2
	3 3 3 4 4	1	1	1
	3 3 3 4	3	1	5
	3 3 1 2 3	3	1	7
	3 3 3 2 3	4	1	7
	3 3 3 3 4	3	1	5
	2 3 2 1 3	3	1	7
	2 3 2 2 3	2	1	5
	3 3 3 3 3	4	2	5
	1 2 2 3	3	2	3
	3 3 3 3 3	3	1	4
	3 3 3 [illegible]	3	1	5
	3 3 3 3 5	3	2	5
	3 2 2 2 [illegible]	2	1	3
	3 2 2 2 3	1	1	3
	3 2 2 2 2	2	1	3
	3 3 3 4 4	1	1	1
	3 3 3 [illegible]	3	[illegible]	[illegible]
	3 3 3 [illegible] 3	1	1	2
	1 3 [illegible] 2	3	1	7
	3 3 2 2	4	1	7
	2 3 3 3 3	2	1	4
	3 3 3 3 3	2	1	2
	[illegible] 3	2	1	3
	3 3	[illegible]	1	4
	3 2 3 2 3	2	1	3
	3 2 3 2 3	3	1	5
	3 2 3 2 3	3	1	5

* Man wore CC-2 impregnated shirts.
** Protective ointment worn on neck.

TABLE VI (Con't.)

Test No. 25* - 3/22/45 — CT = 290 *** — 90 °F. 69% RH

Man No.	1	2	3	4	5	Av.	Min.	Max.
amock	4	2	3	2	2	2	1	3
upst	3	2	3	2	2	4	1	5
lmock	4	2	3	2	2	2	1	3
slav	3					2		
ach	3		1	2	1	3	1	4
aarm	1		1	1		2	1	2
af	3	3	3	2	3	4	1	6
fa	2	1	2	2	1	3	1	7
wr	3	1	2	2	2	3	1	6
saf	3					4		
ax	3	2	2	1	1	3	1	4
lth	3	2	1	2	1	3	1	5
vth	3	3	2	2	1	3	1	6
abd	3	1	2	[illegible]	1	3	2	4
il								
ing								
pen								
ser								
athi	2	1	2	2	2	3	1	5
kn	2	1	2	2	2	3	1	5
aleg	2	1	2	2	2	3	2	5
paur								
pmock	4	2	3	3	2	3	1	5
paf	3	1		2	1	2	1	4
pah	3	1	2	2	1	2	1	4
parm		1	1	1		1	1	1
elb		1	2	2		1	1	1
C7	3	1	2	2	1	2	1	3
sa	3	1	2	2	1	2	1	4
dth	3	1	2	2	3	2	1	4
lumb	3	1				3	1	4
bt								
pthi	2	1	2	2	3	2	1	4
pop	2	1	2	2	3	2	1	5
pleg	2	1	2	2	3	2	1	5

Test No. 26 - 12/1/44 — CT = 597 — 70° F. 62% RH

Man No.	1	2	3	4	5	6	Av.	Min.	Max.
amock	2	1	3	1	2	2	3	1	5
upst	1	1	3		1	1	2	1	4
lmock									
slav									
ach		1		1	1	1	3	2	4
aarm									
af	2	1	1	1	1	2	2	1	5
fa			1				2		
wr	3	1	1	1	1	2	3	1	4
saf			4				1		
ax	3	3	4	3	3	3	1	1	2
lth	1		1				3	2	3
vth		1	1			1	2	1	3
abd	2			1			5	4	6
il									
ing									
pen		1					3		
ser	3	1	5		5	1	5	3	7
athi	2		2	1		1	3	1	5
kn	1	1	2	1	1	2	3	1	5
aleg									
paur									
pmock	2	3	3	1	2	2	2	1	4
paf			4			1	2	1	2
pah	2	3	1	3	1	2	3	1	6
parm	2		2	2	1	2	4	4	5
elb									
C7									
sa	2	3	2	3	1	2	3	1	6
dth	1	1	2	3	1	2	3	1	4
lumb									
bt	2		2	1		1	4	3	5
pthi	2		2	1		1	4	1	7
pop	3		2	2	1	2	4	1	6
pleg						1	3		

Test No. 27 - 1/9/45 — CT = 906 — 64.5° F. 60% RH

Man No.	1	2	3	4	5	6	7	8	Av.	Min.	Max.
amock	3	2	3	3	3	2	3	5	4	2	7
upst	3		2	2	2	1	1	3	3	1	5
lmock	2	1	3	3	3	3	3	3	4	1	7
slav	3		2	2	2	1		3	4	2	5
ach				1	1	2			5	5	5
aarm	3			2	1				5	4	5
af	1	2	3	3	2	2	1	2	5	4	5
fa	1	1	1	1	1	1			4	1	5
wr	2	1	2	2	1	2	1		4	1	5
saf	3	1	5			3	1	2	7	3	15
ax	3	3	5	4	3	5	3	4	5	1	13
lth	3	1	2	3		1			4	3	5
vth	5	1	2	3	1	1			4	3	5
abd	3	1	2	3	1	1	1		4	1	5
il				2					1		
ing	3	2	3	3	2				5	4	5
pen	1	5	5	2		5	1	5	12	2	20
ser	5	5	5	5	2	5	5	5	8	4	13
athi	3	1	1	3	1	2	1		5	4	6
kn	3	1	1	3		2	1		5	4	6
aleg	3	1		1		1			6	5	7
paur											
pmock	2	1	3	2	1	2	1	1	3	1	5
paf	3		5	3		5		1	6	1	15
pah	2	1	1	[illegible]	1	2		1	2	1	4
parm	3		2			1			5	5	5
elb	1		2	1		1	1		4	2	6
C7	3	1	1	2	1	1	1	1	3	1	5
sa	3	1	2	3	1	2		1	3	1	5
dth	3	1	1	3	1	1		1	2	1	5
lumb	3			2					5	4	5
bt	3	3	1	3		2	3		5	5	6
pthi	3	2	1	3		1	1		5	5	6
pop	3	2	2	3	1	2	2		5	5	7
pleg	3	1	1	3		1			6	5	7

Test No. 28 - 1/8/45 — CT = 506 — 70° F. 46% RH

Man No.	1	2	3	4	5	6	7	8	Av.	Min.	Max.
amock	3	3	3	2	4	3	5	3	3	1	6
upst	2	2	2	2	1	2	1	3	1	1	2
lmock	3	3	3	2	3	5	5	5	3	1	6
slav	3	2			1	2	1	3	4	1	6
ach	3	1				2	1	3	4	1	6
aarm	3				1	1	1	2	4	2	6
af	3	1	2	2	3	3	3	2	3	1	6
fa	3	1		1	2	3	3	2	3	1	6
wr	3	1	2	2	3	3	5	3	4	1	7
saf	3	2		1	3	3	3	3	4	1	7
ax	5	3	2	4	4	3	4	3	5	2	9
lth	3	1		1	2	3	3	3	4	1	6
vth	3	1		1	2	3	1	2	3	1	5
abd	3	2		1	1	1	1	1	3	1	6
il		2							1		
ing	2	3			3	3	4	3	4	1	6
pen	5	5	5	5	5	5	5	4	17	10	21
ser	5	5	5	5	5	5	5	5	9	8	14
athi	3	1			1		2	2	4	3	6
kn	2	1	1	1	2	1	2	2	4	1	6
aleg	2				1	1	1		5	4	6
paur	2	2	1						1	1	1
pmock	3	3	2	2	2	2	2	3	3	1	6
paf	3	2	1	2	3	3	3	3	4	1	7
pah	3	2	1	2	1	1	1	2	1	1	4
parm	2		1	1	1	1		2	3	1	6
elb	2	1	1	1	2	1		2	2	1	6
C7	3	1	1	2		1		2	1	1	2
sa	3	2	1	2	1	1	1	2	2	1	4
dth	3	1	1	2	1	1	1	1	2	1	4
lumb	2								1		
bt	2	1		1	2	2	1	2	3	1	7
pthi	2	1	1		1	1	2	1	5	1	6
pop	3	2	1	2	2	2	2	2	5	1	6
pleg	2	1	1	1	1	1	1	1	5	1	6

Test No. 29* - 1/11/45 — CT = 592 — 60.5° F. 57% RH

Man No.	1	2	3	4	5	6	7	8	Av.	Min.	Max.
amock	3	3	1	4	3	2	4	3	3	1	5
upst	2	1		3	2	1	2	2	2	1	4
lmock	3	1	2	4	3	2	4	3	3	1	5
slav	2	1		3	2	1	2	2	4	3	5
ach	2	2		2	3		1	2	4	3	8
aarm	2	2		1				1	3	2	4
af	3	3	2	3	3	1	1	1	3	1	5
fa	1	1	1	1	1			1	3	1	4
wr	2	1	1	1	2	1	1	1	2	1	4
saf	3	3	3	3	5	3	5	2	5	3	13
ax	4	3	5	5	5	3	4	3	6	2	15
lth		2	1	2	1	1	2	2	3	3	4
vth	2	1	1	2	3	3	1	2	5	3	8
abd	2	1	1	2	1	3	1	2	4	3	5
il											
ing											
pen											
ser				1	1			2	2	2	3
athi	2	1	1	3	1	1	1	1	4	3	6
kn	2	1	1	3	1	1	1	1	3	2	6
aleg											
paur											
pmock	3	1	2	3	2	2	2	3	4	1	6
paf	3	3	5	3	5	5	3	2	5	2	15
pah	3	3		2	2	1	1	2	3	1	4
parm		2			1			1	3	3	3
elb	1	1	1	1	1	1		1	3	1	4
C7	3	1		3	1	1	1	2	4	1	5
sa	3	1		2	2	2	1	2	3	1	4
dth	3	1		2	2	3	1	1	4	1	5
lumb					1	3			5	4	5
bt	1	1		1	1		1	1	5	4	6
pthi	1			3	1			1	4	3	6
pop	1	1	1	1	1	1	1	1	3	2	3
pleg	1				1			1	4	4	5

Test No. 30 - 1/12/45 — CT = 596 — 59.5° F. 62% RH

Man No.	1	2	3	4	5	6	7	8	Av.	Min.	Max.
amock	3	3	3	3	3	3	3	2	3	1	4
upst	2	3	1	3	2	1	2	2	3	1	5
lmock	3	3	3	3	3	3	3	2	3	1	4
slav	2	3		3	2	3	2	2	4	2	5
ach	2	3	1	1	1		1		3	2	5
aarm	2	1						1	3	3	4
af	2	2	3	3	1	1	3	2	3	2	4
fa	1	1	1	1			1	1	2	1	3
wr	1	1	1	1	2	1	2	1	1	1	2
saf	3	3	3	3	5	3	5	3	7	1	16
ax	3	5	5	4	3	4	5	4	6	1	10
lth	3	2	3	3	3		2		4	3	6
vth	3	3		3	3		2	1	4	3	6
abd	3	2		3	3		2		4	3	4
il											
ing	3	3	3		3		3		4	4	6
pen	5	5	5	5	5	5	5	2	15	6	20
ser	5	5	5	5	5	5	5	5	12	5	16
athi	3	1	2	1	3		2	1	4	2	7
kn	2	1	2	1	1	1	[illegible]	1	3	2	5
aleg	1	1					1		3	3	3
paur	3	2							4	3	4
pmock	3	3	3	2	2	2	2	2	3	1	5
paf	5	5	3	3	5	3	5	3	8	3	14
pah	3	3	2	1	1	1	2	1	3	1	5
parm	2	1		1	1		1	1	2	2	3
elb	2	1		1	1		1	1	2	2	3
C7	3	3		1	1	1	2	1	2	1	3
sa	3	3		1	1	1	2	1	2	2	3
dth	3	3		1	1	1	2	1	3	2	4
lumb	3	2		1					3	3	4
bt	5	3	1	1	3	1	3	1	4	2	8
pthi	1	1	1	1	3		1	1	4	3	7
pop	1	1	1	1	3	2	1	1	3	2	5
pleg	1	1		1			1	1	3	2	3

Test No. 31* - 3/10/45 — CT = 600 — 64.5° F. 69% RH

Man No.	1	2	3	4	5	6	7	Av.	Min.	Max.
amock	2	4	3	4	4	4	4	2	1	4
upst	1	3	2	3	1	2	3	3	1	7
lmock	2	4	3	4	4	4	4	2	1	4
slav	1	3	1	2	3	2	1	3	1	6
ach		3				2		4	1	7
aarm		3	3	2		2		4	1	7
af	1	3	3	3	3	3	1	4	1	6
fa			1	1		2		1	1	1
wr	1	3	2	2		2	1	3	1	6
saf		4			3			5	3	6
ax		4	3	4	3	4	4	4	1	7
lth		3	3	2	3	2	2	4	1	7
vth		3	1	2	3	2	1	3	1	6
abd		3	1	2	1	2	2	4	1	6
il										
ing										
pen										
ser										
athi	1	2	2	2	2	1	1	3	1	5
kn	1	2	2	2	2	1	1	3	1	5
aleg	1	2	2	2	2	1	1	3	2	5
paur										
pmock	2	4	3	3	3	4	3	3	1	4
paf		4	3	2	3	3		3	1	6
pah	1	2	1	2	3	3	2	3	1	6
parm						2		1		
elb	1		1	2		2		2	1	2
C7	1	3	1	2	3	2	2	2	1	5
sa	1	3	1	2	2	2	2	3	1	7
dth	1	3	1	2	2	3	2	2	1	5
lumb		3			1	3		2	1	3
bt					1	2		3	1	5
pthi	1	1	1	[illegible]	1	1	1	2	1	5
pop	1	3	1	1	1	1	1	3	1	6
pleg	1	1	1	1	1	1	1	2	1	5

Test No. 32* - 1/10/45 — CT = 596 — 69.5° F. 92% RH

Man No.	1	2	3	4	5	6	7	8	Av.	Min.	Max.
amock	3	4	3	4	3	4	2	4	4	1	5
upst		3	1	3	2	2		3	3	1	5
lmock		1	3	4	2	4	1	4	4	1	5
slav	1	3	1	3	1	2			3	2	5
ach	2	2		2	1	2		2	4	3	5
aarm				3	1	1			4	3	4
af	3	2	1	3	2	3	2	3	4	3	5
fa		1	1	3	1	1		2	4	3	5
wr	1	1	1	3	2	2		2	3	1	5
saf	3	3		5	5	5		5	11	2	16
ax	5	3		5	5	5	5	5	5	2	15
lth	2	2		3	2	3		1	4	2	5
vth	1	3		3	1	2		2	3	1	4
abd		3		2	1	3	1	2	4	3	5
il											
ing				2					4		
pen				1					4		
ser				2				1	3	1	4
athi	1	1	1	1		1		1	4	3	5
kn	1	2	1	2	1	1	1	1	4	4	5
aleg	1	1		1					5	5	5
paur											
pmock	1	2	2	3	1	3		3	3	1	5
paf	3	3		5	5	5		5	9	2	16
pah	1	2	1	3	1	3		2	3	1	5
parm		1	1	3	1	1		2	3	1	5
elb		1	1	3	1	1		1	3	1	5
C7	1	2		3	2	3		1	2	1	4
sa	1	2	1	3	2	3	1	1	2	1	4
dth	1	2	1	3	1	3		2	3	1	5
lumb		2		2	1	3			[illegible]	4	5
bt	1	1	1	1		1			3	5	5
pthi	1	1	1	1		1	1	1	4	1	5
pop	1	2	1	1		1	1	2	4	1	5
pleg	1	1	1	1		1			4	1	5

Test No. 33* - 1/13/45 — CT = 645 — 60° F. 67% RH

Man No.	1	2	3	4	5	6	7	8	Av.	Min.	Max.
amock	3	3	1	3	3	1	3	3	2	1	3
upst	2	3	1	3	2		3	2	2	1	3
lmock	3	3	1	3	3	1	3	3	2	1	3
slav	2	3	1		2		3	1	2	1	3
ach		1			1	1	1		2	1	3
aarm	1	1					1		2	2	3
af	2	2		2	1	1	5	2	2	1	3
fa	1	1	1		1		1	1	2	1	3
wr	1	1	1	1	1	1	1	1	2	1	2
saf	3	3	3	3	3	3	3	2	3	2	4
ax	4	4	3	3	3	3	5	1	5	1	13
lth	1	3	1	1	2	1	2	[illegible]	3	1	6
vth	1	1	2		2	1	[illegible]	1	2	1	4
abd	2	1	2	1	1	1	2	1	2	1	4
il											
ing											
pen											
ser				1		1		1	1	1	2
athi	1	1	1		1	1	1	1	2	1	2
kn	1	1	1	1	1	1	1	1	2	1	2
aleg					1				2		
paur											
pmock	2	3	1	3	1	1	3	2	2	1	3
paf	3	3	3	3	1	3	5	1	4	2	13
pah	2	2	1	[illegible]	1	1	2	1	2	1	4
parm	1	1	1		1		1		1	1	2
elb	1	1			1		1		2	1	2
C7	1	2	1		2	1	2	1	3	1	6
sa	2	2	1	1	3	1	2	1	2	1	3
dth	2	2	1		3	1	1	1	2	1	3
lumb	1				1				4	[illegible]	4
bt	1	1	1	1	1	2	1	1	2	1	3
pthi		1	1		1		1		2	1	2
pop	1	[illegible]	1	1	1	1	2	1	1	1	1
pleg			1		1		1		2	2	2

* Men wore CC-2 impregnated shorts.
*** Men presoaked prior to chamber exposure.

TABLE VII

NUMBER OF MEN IN EACH TEST SHOWING MAXIMUM REGIONAL READINGS OF A GIVEN INTENSITY. AVERAGE REGIONAL INTENSITIES.

Intensity	Test No. 1 3/23/44 CT = [illegible] 90° F. 69% RH [illegible] 1 2 3 4 5 Av.
[illegible]	2 0.3
[illegible]	
[illegible]	1 0.2
[illegible]	1 0.2
[illegible]	1 0.2
[illegible]	
[illegible]	
[illegible]	1 0.2
[illegible]	1 0.2
[illegible]	
[illegible]	

Intensity	Test No. 2 7/25/44 CT = 50 90° F. 69% RH 5 min 1 2 3 4 5 Av.
[illegible]	2 2 1.2
[illegible]	1 0.6
[illegible]	2 0.4
[illegible]	1 0.2
[illegible]	4 0.8
[illegible]	4 1 1.2
[illegible]	1 1 0.6
[illegible]	
[illegible]	
[illegible]	1 0.2
[illegible]	2 0.4
[illegible]	1 0.2
[illegible]	4 1 1.2
[illegible]	2 0.4
[illegible]	1 0.2
[illegible]	2 0.4

Intensity	Test No. 3 3/30/44 CT = 100 90° F. 69% RH 6 min 1 2 3 4 5 Av.
[illegible]	3 2 1.2
[illegible]	1 0.3
[illegible]	1 0.2
[illegible]	1 2 0.8
[illegible]	2 1 0.7
[illegible]	2 0.7
[illegible]	3 2 1.2
[illegible]	1 0.3
[illegible]	
[illegible]	1 0.3
[illegible]	3 2 1.2
[illegible]	2 0.5
[illegible]	
[illegible]	2 0.7
[illegible]	1 2 0.8
[illegible]	3 1 0.8
[illegible]	4 2 1.5
[illegible]	
[illegible]	5 0.8

Intensity	Test No. 4 7/25/44 CT = 150 90° F. 69% RH 5 min 1 2 3 4 5 Av.
[illegible]	4 1.6
[illegible]	2 2 1 1.8
[illegible]	1 1 0.6
[illegible]	2 1 1.0
[illegible]	1 3 1 2.0
[illegible]	2 0.4
[illegible]	4 1 1.2
[illegible]	1 3 1 2.0
[illegible]	
[illegible]	1 1 0.8
[illegible]	2 0.4
[illegible]	
[illegible]	2 1 0.8
[illegible]	2 1 2 2.0
[illegible]	
[illegible]	2 0.4
[illegible]	2 0.4

Intensity	Test No. 5 1/25/45 CT = 100 100° F. 39% RH 6 min 1 2 3 4 5 Av.
[illegible]	3 3 1.5
[illegible]	1 0.2
[illegible]	5 1 1.2
[illegible]	5 0.8
[illegible]	3 0.5
[illegible]	3 0.5
[illegible]	5 0.8
[illegible]	1 0.2
[illegible]	
[illegible]	4 1 1.1
[illegible]	6 1.0
[illegible]	2 0.3
[illegible]	6 1.0
[illegible]	6 1.0
[illegible]	5 0.8
[illegible]	2 0.3
[illegible]	1 0.2

Intensity	Test No. 6 1/25/45 CT = 130 100° F. 67% RH 6 min 1 2 3 4 5 Av.
[illegible]	4 1 1 1.5
[illegible]	5 1 1.2
[illegible]	5 1 1.2
[illegible]	1 0.2
[illegible]	4 0.8
[illegible]	2 1 0.7
[illegible]	
[illegible]	
[illegible]	2 0.3
[illegible]	6 1.0
[illegible]	
[illegible]	1 1 0.5
[illegible]	6 1.0
[illegible]	4 1 1.0
[illegible]	5 0.5
[illegible]	2 0.3
[illegible]	2 0.3

Intensity	Test No. 7 4/4/44 CT = 150 90° F. 69% RH 10 min 1 2 3 4 5 Av.
[illegible]	2 0 2 2.0
[illegible]	1 0.2
[illegible]	3 1.1
[illegible]	7 1 1 1.4
[illegible]	3 5 0.9
[illegible]	1 0.2
[illegible]	6 4 1.4
[illegible]	1 0.2
[illegible]	
[illegible]	2 0.8
[illegible]	3 0.5
[illegible]	2 1 0.4
[illegible]	
[illegible]	4 5 1.0
[illegible]	5 4 1.1
[illegible]	
[illegible]	5 1 0.7
[illegible]	
[illegible]	5 1 0.7

Intensity	Test No. 8 7/[illegible]/44 CT = 150 90° F. 69% RH 6 min 1 2 3 4 5 Av.
[illegible]	0 5.0
[illegible]	6 5.0
[illegible]	1 1 0.8
[illegible]	2 4 2.7
[illegible]	6 5.0
[illegible]	1 1 3 2.0
[illegible]	2 4 2.7
[illegible]	5 1 3.2
[illegible]	1 0.5
[illegible]	3 0.5
[illegible]	2 1 3 2.2
[illegible]	2 2 1 1.5
[illegible]	
[illegible]	1 2 3 2.5
[illegible]	6 5.0
[illegible]	1 1 0.7
[illegible]	4 2 1.5
[illegible]	1 5 1 1.7
[illegible]	4 2 1.5

Intensity	Test No. 9 11/20/44 CT = 200 70° F. 53% RH 7 min 1 2 3 4 5 Av.
[illegible]	3 2 1.0
[illegible]	4 2 1.4
[illegible]	3 1 0.7
[illegible]	3 1 0.7
[illegible]	1 0.1
[illegible]	3 1 0.7
[illegible]	
[illegible]	3 0.4
[illegible]	
[illegible]	1 0.4
[illegible]	
[illegible]	2 0.3
[illegible]	3 0.4

Intensity	Test No. 10 1/23/45 CT = 200 80° F. 66% RH 6 min 1 2 3 4 5 Av.
[illegible]	3 2 1 1.7
[illegible]	3 0.5
[illegible]	4 0.7
[illegible]	4 0.7
[illegible]	3 1 0.8
[illegible]	
[illegible]	
[illegible]	2 1 1 1.5
[illegible]	6 1.0
[illegible]	
[illegible]	1 0.2
[illegible]	3 1 0.8
[illegible]	2 2 1.0
[illegible]	3 0.5
[illegible]	4 0.7
[illegible]	2 0.3

Intensity	Test No. 11 1/23/45 CT = 200 80° F. 66% RH 5 min 1 2 3 4 5 Av.
[illegible]	3 3 1.6
[illegible]	2 0.4
[illegible]	2 0.4
[illegible]	2 0.4
[illegible]	2 0.4
[illegible]	
[illegible]	4 0.8
[illegible]	2 0.4
[illegible]	3 1 1.0
[illegible]	5 1.0
[illegible]	2 0.4
[illegible]	2 0.4

Intensity	Test No. 12 1/21/45 CT = 240 90° F. 69% RH 10 min 1 2 3 4 5 Av.
[illegible]	4 2 2.2
[illegible]	1 3 2 1.5
[illegible]	1 1 1.0
[illegible]	3 4 1 1.4
[illegible]	3 2 2 1.5
[illegible]	2 0.4
[illegible]	2 4 3 1.9
[illegible]	4 5 1.0
[illegible]	
[illegible]	3 0.5
[illegible]	3 2 3 1 2.1
[illegible]	5 2 0.9
[illegible]	
[illegible]	3 3 2 1 1.5
[illegible]	3 4 1 2.6
[illegible]	2 4 1.0
[illegible]	3 2 0.7
[illegible]	2 0.8
[illegible]	5 2 0.7

Intensity	Test No. 13 7/27/44 CT = 200 90° F. 69% RH 6 min 1 2 3 4 5 Av.
[illegible]	2 2 2 4.0
[illegible]	4 1 2.0
[illegible]	2 1 1 1 2.7
[illegible]	5 1 3.2
[illegible]	1 4 1 3.7
[illegible]	1 3 1.8
[illegible]	4 1 1 3.5
[illegible]	6 5.0
[illegible]	
[illegible]	1 0.3
[illegible]	3 1 2 3.2
[illegible]	1 5 2 2.8
[illegible]	
[illegible]	1 4 1 3.8
[illegible]	6 5.0
[illegible]	1 3 1 1.5
[illegible]	2 3 1.5
[illegible]	2 2 1.0
[illegible]	4 1 1.0

Intensity	Test No. 14 1/27/45 CT = 200 100° F. 66% RH 6 min 1 2 3 4 5 Av.
[illegible]	1 2 1 4.0
[illegible]	1 3 2.8
[illegible]	4 5.0
[illegible]	4 5.0
[illegible]	1 1 2 2.5
[illegible]	1 3 2.8
[illegible]	1 3 2.8
[illegible]	1 3 2.5
[illegible]	
[illegible]	1 0.8
[illegible]	1 3 4.4
[illegible]	2 2 2.5
[illegible]	
[illegible]	4 5.0
[illegible]	3 1 5.1
[illegible]	1 3 2.8
[illegible]	1 1 2.8
[illegible]	1 1 2 2.5
[illegible]	2 1 1 1.8

Intensity	Test No. 15 4/17-22/44 CT = 250 90° F. 69% RH 15 min 1 2 3 4 5 Av.
[illegible]	1 7 7 2.4
[illegible]	1 6 1 2 2.0
[illegible]	4 8 2 1.7
[illegible]	1 5 3 1.5
[illegible]	4 6 3 1.7
[illegible]	1 7 2 1.4
[illegible]	8 6 5 2.2
[illegible]	3 3 5 1.2
[illegible]	
[illegible]	1 1 0.5
[illegible]	6 6 1 1.4
[illegible]	2 5 2 6 3.2
[illegible]	4 2 3 1 1.4
[illegible]	
[illegible]	3 7 4 1.9
[illegible]	3 8 1 3 2.5
[illegible]	7 6 2 1.7
[illegible]	10 3 1 1.5
[illegible]	2 6 0.9
[illegible]	8 4 1 1.5

Intensity	Test No. 16 7/28/44 CT = 250 90° F. 69% RH 6 min 1 2 3 4 5 Av.
[illegible]	1 5 2 4.2
[illegible]	5 1 3.2
[illegible]	2 1 8 3.3
[illegible]	1 5 2.8
[illegible]	4 2 3.5
[illegible]	4 1 2.7
[illegible]	1 5 2.8
[illegible]	4 1 1 3.5
[illegible]	4 2.0
[illegible]	1 5 1.8
[illegible]	1 2 1 2 3.7
[illegible]	2 4 2.7
[illegible]	
[illegible]	5 1 4 2 3.2
[illegible]	5 2 1 3.7
[illegible]	1 8 2.0
[illegible]	1 5 1.8
[illegible]	1 2 5 2.5
[illegible]	1 2 2 1.8

TABLE VII (Cont'd.)

Test No. 17
11/28/45
CT = 500
70° F. 65% RH
6 mos

Immunity	1	2	3	4	5	Av.
Nil						1.7
			1	5		8.8
		5	1			1.2
		6				1.0
		1	1			0.5
			1			0.5
		6				1.0
			1			0.5
		1	1			0.5
		8	1	1		2.0
		1				0.2
			4			0.7
		6				1.0
			5			1.0
		5	5			1.5
			2			0.7

Test No. 21*
1/13/45
CT = 500
90° F. 57% RH
7 mos

Immunity	1	2	3	4	5	Av.
Nil			7			3.0
			7			3.0
		8	8			8.0
		8	8	2	1	8.3
		8	5			1.9
		4	5			1.9
		8	8	3		8.1
		5	1	5		8.0
			8	8		8.0
			2			0.9
		2	8	2		1.7
		3	2	4		1.9
		2	1	1		1.9
		4	5			2.4
		4	1			1.1
		5	2			1.3

Test No. 25**
1/22/45
CT = 500
90° F. 65% RH
5 mos

Immunity	1	2	3	4	5	Av.
Nil		2	1	1		2.8
				1	5	8.0
		8	2	1		1.8
		8	2	1		1.8
		1	3	8		8.2
		8	2	1		1.8
		1	2	8		8.2
		8	2	1		1.8
		8	5			1.6
		1	4			8.8
		1	5	1		8.0
		1	5	1		8.0
		1	5	1		8.0
		1	5	1		8.0

Test No. 99*
1/11/46
CT = 600
60° F. 57% RH
8 mos

Immunity	1	2	3	4	5	Av.
Nil				4	4	4.0
			3	8	3	4.0
		1	5	3		8.0
		8	5	8		1.0
		5	3	2		1.9
		3	4			1.4
		8	2	2		1.6
		8	3	1		1.4
		2	1			0.5
		6				0.6
		6	9			1.3
		5	1	4		8.2
		6	2			1.3
		6	1	1		1.4
		8				1.0
		3				0.4

Test No. 18
1/24/45
CT = 500
90° F. 65% RH
4 mos

1	2	3	4	5	Av.
			4		3.5
			5	1	8.5
		1	2	1	8.0
		2	2		1.5
		2	1		1.0
		2	2		1.5
		2	2		1.5
		1	1		0.8
			1		0.5
		1	2		1.3
		5	1		1.3
		1	1	5	2.5
		1	1		0.8
		3			0.8
		2			0.5
		2			0.5

Test No. 22**
11/27/44
CT = 500
90° F. 65% RH
5 mos

1	2	3	4	5	Av.
					**
			4		8.4
		1	8	2	2.2
		1	1	5	8.4
		1	2	3	8.4
		1	4		8.4
			5	1	8.4
		1	1	5	8.4
		1			0.8
		1			0.8
		3	1		1.0
		1	1		0.4
		1	5	1	8.8
			5	1	8.4
		5	1		1.0
		1	2	1	1.6
		1	5	1	8.0
			5	1	1.4

Test No. 26
12/1/44
CT = 500 +++
70° F. 65% RH
6 mos

1	2	3	4	5	Av.
1	5	3			2.2
			5	1	8.8
		8	2	2	2.0
		9		1	0.5
		2		1	0.9
		5	2	1	1.7
		1	1		0.5
		1			0.2
		8	1	1	8.5
		8	8		1.0
		1	4		1.5
		4	8		1.3
		1	1	1	1.5
		8	8		1.0
		1	5	1	1.7
		1			0.2

Test No. 30
1/16/45
CT = 600
60° F. 68% RH
8 mos

1	2	3	4	5	Av.
		1	7		2.9
		3	5	4	4.6
		4	8		1.8
		4	8		1.5
		1	1	4	1.9
		1	8		8.0
		4	1	8	1.5
		8	5		1.6
			9		1.9
		1	7		4.6
			8		5.0
		4	5	1	2.5
		6	1		1.0
		2	5		8.1
		6	2		1.3
		4	2	2	1.8
		4	3	1	1.4
		5			0.6

Test No. 31*
1/13/45
CT = 600
60° F. 68% RH
7 mos

1	2	3	4	5	Av.
					3.0
			8	4	5.1
		2	2	3	8.1
		2	3	2	8.0
		2	2	2	1.7
		2	3	3	8.1
		2	3	2	8.0
		2	2	2	1.7
		1	1		0.4
		1	2	2	1.6
		2	3		2.4
		2	3	1	1.6
		5	4		1.6
		6	1		1.3
		5	4		1.6

Test No. 29*
2/25/45
CT = 500
90° F. 56% RH
8 mos

1	2	3	4	5	Av.
					3.0
			2	2	8.5
		4	1	1	1.1
		5	3		1.1
		2			0.8
		1			0.5
		3			1.1
		3			0.3
		1	3		0.5
		1	2		0.6
		7			0.9
		5	1		0.6
		6			0.8
		8			1.5
		6	1		0.8
		6	1		0.8

Test No. 23*
11/27/44
CT = 500
90° F. 65% RH
6 mos

1	2	3	4	5	Av.
			4	2	3.5
			6		5.0
			6		5.0
			6		5.0
		2	6		2.7
		2	5		8.0
		4			5.0
		1	5		8.8
			4		8.0
		1	5	1	8.2
		1	1		0.7
		2	6		2.7
		8	2		2.0
		1			0.5

Test No. 27
1/5/45
CT = 500
60° F. 68% RH
8 mos

1	2	3	4	5	Av.
		1	7		2.9
			8	8	5.0
		4	2	1	1.4
		5	2	2	1.6
		5	1	2	1.4
		2	1	4	1.2
		2	1	2	1.2
		6	1	2	1.5
		8	8		1.3
		8	1	4	5.0
		1	7		4.6
		1	1	4	1.9
		4	2	1	1.4
		8	2	2	2.0
		5	4	2	1.6
		1	4	8	1.9
		5	8		1.1

Test No. 32*
1/10/45
CT = 600
70° F. 58% RH
8 mos

1	2	3	4	5	Av.
			1	4	3.4
		1	6	4	4.1
		8	3	2	1.8
		8	2	2	1.6
		8	4	2	1.5
		1	5	8	1.6
		8	2	2	1.6
		8	2	8	1.5
		1			0.3
		1			0.1
		1			0.3
		5			0.6
		4	1	1	1.1
		1	5	4	0.6
		3	3	2	1.5
		6	2		1.3
		5	8		1.1
		5			0.6

Test No. 28*
2/25/45
CT = 500
60° F. 77% RH
8 mos

1	2	3	4	5	Av.
			2	6	2.8
			2	2	2.3
		1	4	5	8.8
		1	3	4	2.4
		6	2	1	1.5
		4	2	1	1.6
		1	4	5	2.5
		5	2		1.4
		1			0.3
		6	1		1.9
		5	1	2	1.6
		1	1	4	2.4
		2	1	1	0.9
		2	4	2	2.0
		5	4	1	1.8
		5	5	2	1.9

Test No. 24*
5/22/45
CT = 500
90° F. 64% RH
5 mos

1	2	3	4	5	Av.
			3	2	3.4
			5		5.0
			5		5.0
			5		5.0
			5		5.0
			5		5.0
			5		5.0
		1	4		2.8
		4	1		3.2
		3	2		2.4
		2	5		2.6
		2	5		2.6
		2	5		2.6

Test No. 26
1/8/45
CT = 500
70° F. 68% RH
8 mos

1	2	3	4	5	Av.
		1	5	1	3.5
		1	5	3	3.5
		2	3	2	1.9
		2	5	1	1.6
		3	2	2	1.6
		2	1	4	2.0
		6	2	1	1.4
		5	3	1	1.3
		1	4	1	2.5
			1	7	4.9
			8	2	5.3
		5	4		1.4
		5	2	3	2.0
		1	5	4	2.4
		1	2	4	2.8
		4	2	1	1.9
		1	6	1	2.0
		7	1		1.1

Test No. 33*
1/13/45
CT = 700
60° F. 67% RH
8 mos

1	2	3	4	5	Av.
	1	6	2	1	2.5
	1	4	2	1	5.4
	5	5			1.4
	4	3	1		1.6
	4	5			1.9
	3	2	1		1.5
	4	2	1		1.4
	5	3			1.4
		7	1		1.1
	6	1			0.8
	2	4	1		1.6
	8				1.0
	8				1.0
	7	1			1.1
	9				0.4

* = Rx were OC-2 impregnated charts.
** = Protective statement were on test.
Rx = Rx presented prior to chamber exposure.

TABLE VIII

Total Damage Indices

Test No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
CT	50	50	100	100	100	100	150	150	200	200	200	200	200	200	250	250
Temp.	90	90	90	90	100	100	90	90	70	80	80	90	90	100	90	90
RH	65	65	65	65	35	67	65	65	53	46	86	65	65	66	65	65
Month	Mar	Jul	Mar	Jul	Jan	Jan	Apr	Jul	Nov	Jan	Jan	Apr	Jul	Jan	Apr	Jul
No. Men	6	5	6	5	6	6	10	6	7	6	5	10	6	4	15	6
neck	0.7	2.9	2.9	3.8	3.6	3.6	4.8	7.2	2.4	4.1	3.8	5.3	9.6	9.6	5.8	10.1
ax		1.7	0.8	5.0	0.6		0.6	8.4	3.9	1.4	1.1	3.6	7.8	7.8	5.6	9.0
sh		2.4	1.2	3.5	7.1	7.1	6.5	4.7	4.1	4.1	2.4	10.6	15.9	17.7	10.0	19.5
sc	0.7	0.7	2.6	3.3	2.6	4.0	4.6	8.9	2.3	2.3	1.3	4.6	10.6	9.9	4.3	9.3
vth	1.2	4.8	4.2	12.0	3.0	1.2	5.4	19.0	0.6			7.8	19.2	13.8	10.2	19.8
lth			2.7	1.4	1.8	0.7	0.7	7.0				1.4	6.3	9.8	4.9	9.5
dth	1.1	6.4	6.4	6.4	4.2	3.7	7.4	14.3	3.7	4.2	2.1	10.0	18.6	14.5	11.7	14.8
cbd		6.7	3.3	22.2	2.2		2.2	35.6				11.1	33.3	27.8	13.3	39.0
ing								0.7						1.9	0.7	4.8
pen			0.3				0.2	0.6				0.3	0.3		1.5	2.0
sor		0.2	1.3	0.9	1.4	0.3	0.3	2.4	0.4	1.7		2.3	3.5	5.3	3.5	4.1
bt		2.5	1.9	2.5	6.3	6.3	2.5	9.5		6.3	5.0	5.7	14.0	15.3	8.8	17.0
arms	2.9	2.9	10.2	11.7	4.4	7.3	14.6	33.6		2.9	5.8	27.8	46.7	43.8	27.8	46.7
of		1.1	0.7	1.8	0.9	0.9	1.0	2.7	0.4	0.7	0.9	2.3	2.7	3.0	2.1	3.3
hands	0.3		1.2		1.4	1.4		1.0		1.4	1.4	1.4	2.1	3.9	2.4	2.8
thi		9.0	29.1	9.0	17.9	11.2	15.7	29.1	6.7	11.2	8.9	15.7	33.6	62.7	29.1	40.3
pop		0.3		0.7	0.5	0.5		2.9	0.7	1.2	0.7	0.3	1.7	3.9	1.5	3.9
leg		3.1	6.2		1.5	2.3	5.4	10.0		2.3		5.4	7.7	13.9	10.0	13.9
TDI	6.9	44.7	74.9	84.2	59.4	50.5	72.0	196.6	25.2	43.8	33.4	115.6	233.6	265.4	153.2	269.8
TDI*	6.9	42.0	71.4	80.8	51.7	43.9	69.0	183.4	24.8	35.8	28.4	107.3	215.8	243.4	138.7	241.9

* Corrected to exclude area covered by protective shorts.

TABLE VIII (Con't.)

Total Damage Indices

Test No.	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
CT	300	300	300	300	300	300	300	300	300	400	500	500	600	600	600	600	700
Temp.	70	80	85	85	90	90	9-	90	90	70	60	70	60	60	65	70	60
RH	60	85	36	77	37	65	65	65	65	62	60	48	57	62	69	52	67
Month	Nov	Jan	Feb	Feb	Mar	Apr	Nov	Mar	Mar	Dec	Jan	Jan	Jan	Jan	Mar	Jan	Jan
No. Men	6	4	8	8	7	5	6	5	5	6	8	8	8	8	7	8	8
neck	4.1	7.2	3.6	6.7	7.2	2.4	7.9	8.2	7.2	5.3	7.0	7.9	7.2	7.0	8.6	8.2	6.0
ax	7.8	6.4	6.4	6.4	8.4	6.7	8.4	8.4	8.4	9.0	10.6	9.8	11.2	12.9	8.7	11.5	9.5
sh	7.1	11.8	6.5	13.6	11.8	13.0	17.7	17.7	11.8	11.8	8.3	11.2	11.8	10.6	12.4	10.6	8.3
sc	3.3	5.0	3.6	7.9	7.6	7.9	9.9	9.9	7.6	7.3	5.3	5.3	5.9	5.0	6.6	5.9	5.3
vth	3.0	6.0	1.8	9.0	11.4	14.4	16.2	18.0	11.4	3.0	6.4	9.6	11.4	11.4	10.2	9.0	7.8
lth	1.1	5.3	1.1	5.6	6.7	9.1	9.8	10.5	6.7	1.1	4.6	7.0	4.9	7.0	7.4	5.6	5.3
dth	5.3	8.0	5.8	12.2	11.1	13.8	15.9	15.9	11.1	9.0	7.4	7.4	8.5	8.0	10.6	8.5	7.4
abd		8.9	3.3	15.6	22.2	26.6	31.0	33.3	22.2	5.6	15.6	14.4	17.8	17.8	18.9	16.6	15.5
ing	1.2	1.2				0.5					3.1	5.5		4.6		0.7	
pen	0.6		0.3			0.2				0.2	3.3	5.4		5.0		0.1	
scr	2.2		0.7	0.3		1.1				2.8	5.1	5.5	0.6	5.5		0.3	
bt	1.3	8.2	5.7	6.3	5.7	3.8			5.7	6.3	12.0	8.8	5.0	14.5	2.5	3.8	6.9
arms	10.2	19.0	8.8	23.4	24.8	40.8	29.2	40.9	24.8	21.9	20.4	29.2	19.0	14.6	23.4	16.1	11.7
ef	0.9	2.3	0.7	2.2	1.7	2.3	2.9	2.9	1.7	1.2	1.8	2.2	1.9	1.9	2.2	2.2	1.4
hands		1.1	0.4	1.3	2.7	1.4	1.0	3.4	2.7	2.1	2.0	3.9	1.8	1.8	2.2	2.1	1.4
thi	22.4	17.9	22.4	44.4	31.4	35.8	60.5	58.2	31.4	22.4	35.9	42.5	31.3	40.3	35.8	29.1	22.4
pop	2.6	0.9	1.4	3.1	1.9	3.4	3.4	4.4	1.9	2.9	3.2	3.4	1.7	3.7	2.2	1.9	1.9
leg	5.4	7.9		14.6	10.0	13.9	2.3	20.0	10.0	1.5	8.5	8.5	3.1	4.6	12.3	4.6	3.1
TDI	78.5	113.1	72.5	173.0	164.6	197.1	216.1	198.7	164.6	113.4	113.5	187.5	143.1	176.2	164.0	136.8	113.9
TDI*	73.2	103.7	65.8	166.4	158.9	191.5	216.1	198.7	158.9	104.1	138.4	162.3	138.5	146.6	161.5	131.9	107.9

* Corrected to exclude area covered by protective shorts.

TABLE IX

Average Percentage of Skin Area per Man showing Moderate Erythema or Worse

Test No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
CT	50	50	100	100	100	100	150	150	200	200	200	200	200	200	250	250
Temp.	90	90	90	90	100	100	90	90	70	80	80	90	90	100	90	90
RH	65	65	65	65	35	67	65	65	53	46	86	65	65	66	65	65
Month	Mar	Jul	Mar	Jul	Jan	Jan	Apr	Jul	Nov	Jan	Jan	Apr	Jul	Jan	Apr	Jul
No. Men	6	5	6	5	6	6	10	6	7	6	5	10	6	4	15	6
neck		4.8	4.8	9.6	7.2	4.8	19.2	14.4	4.8	7.2	7.2	24.0	14.4	9.6	33.6	14.4
ax		2.8	2.8	8.4			2.8	16.8	5.6			14.0	14.0	11.2	30.8	16.8
sh				5.9	5.9	5.9	17.7	11.8	5.9			47.2	29.5	23.6	59.0	29.5
sc			6.6	3.3		3.3	3.3	19.8				16.5	19.8	13.2	26.4	19.8
vth			6.0	24.0			18.0	36.0				24.0	36.0	18.0	54.0	36.0
lth			7.0				3.5	14.0				7.0	14.0	14.0	31.5	17.5
dth		5.3	10.6	5.3		5.3	21.2	31.8	5.3			37.1	31.8	21.2	68.9	31.8
abd		11.1	11.1	44.4			11.1	66.6				33.3	66.6	33.3	66.6	66.6
ing																
pen			1.1					2.4						2.4	4.8	9.6
scr			2.2	1.1	1.1			4.4		2.2		6.6	1.1	4.4	7.7	4.4
bt							6.3	18.9				12.6	6.6		14.3	6.6
arms			29.2	14.6		14.6	43.8	73.0				87.6	31.5	25.2	37.8	37.8
of		0.9	1.8	2.7			3.6	5.4	0.9	0.9	0.9	9.0	87.6	58.4	160.6	87.6
hands			1.4			1.4		1.4		2.8		5.6	5.4	3.6	10.8	5.4
thi			44.8				22.4	44.8				44.8	2.8	5.6	11.2	4.2
pop								6.8					67.2	89.6	89.6	89.6
leg							7.7	15.4				15.4	3.4	5.1	10.2	8.5
Tot. Av.	0.0	5.0	21.6	23.9	2.4	5.9	18.1	64.0	3.2	2.2	1.6	38.5	7.7	15.4	38.5	30.8
Tot. Av.*	0.0	5.0	21.0	23.6	2.2	5.9	17.4	59.7	3.2	1.8	1.6	36.6	73.2	88.5	50.4	86.2
													66.7	80.5	46.1	76.4

* Corrected to exclude area covered by protective shorts.

TABLE IX (Con't.)

Average Percentage of Skin Area per Man showing Moderate Erythema or Worse

Test No.	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
CT	300	300	300	300	300	300	300	300	300	400	500	500	600	600	600	600	700
Temp.	70	80	85	85	90	90	90	90	90	70	60	70	60	60	65	70	60
RH	60	85	36	77	37	65	65	65	65	62	60	46	57	62	69	52	67
Month	Nov	Jan	Feb	Feb	Mar	Apr	Nov	Mar	Mar	Dec	Jan	Jan	Jan	Jan	Mar	Jan	Jan
No. Men	6	4	8	8	7	5	6	5	5	6	8	8	8	8	7	8	8
neck	9.6	9.6	7.2	19.2	16.8	4.8	14.4	12.0	12.0	12.0	19.2	19.2	19.2	19.2	16.8	19.2	14.4
ax	16.8	11.2	16.8	16.8	19.6	11.2	16.8	14.0	11.2	16.8	22.4	22.4	22.4	22.4	16.8	19.6	22.4
sh	5.9	17.7	11.8	41.3	29.5	23.6	35.4	29.5	17.7	23.6	17.7	29.5	35.4	23.6	29.5	29.5	17.7
sc		6.6	9.9	23.1	16.5	13.2	19.8	16.5	9.9	16.5	13.2	13.2	16.5	9.9	16.5	13.2	13.2
vth	6.0	6.0		12.0	18.0	24.0	36.0	30.0	24.0		18.0	24.0	30.0	30.0	24.0	24.0	18.0
lth	3.5	7.0	3.5	14.0	10.5	14.0	21.0	17.5	10.5		10.5	17.5	14.0	21.0	21.0	17.5	10.5
dth		10.6	15.9	37.1	26.5	21.2	31.8	26.5	21.2	15.9	10.6	10.6	21.2	15.9	26.5	21.2	15.9
abd		33.3		22.2	44.4	44.4	66.6	55.5	33.3	11.1	33.3	22.2	44.4	55.5	44.4	44.4	33.3
ing	2.4	2.4									9.6	14.4		12.0		2.4	
pen	1.1		1.1								5.5	8.8		8.8			
scr	3.3		2.2	1.1		1.1				3.3	8.8	8.8	1.1	8.8		1.1	
bt		12.6		6.3	12.6	6.3				12.6	31.3	25.2		25.2	6.3		6.3
arms		14.6	14.6	43.8	58.4	58.4	58.4	73.0	43.8	58.4	43.8	73.0	29.2	14.6	58.4	29.2	
cf		2.7		6.3	3.6	3.6	5.4	4.5	4.5	1.8	5.4	6.3	4.5	5.4	4.5	6.3	4.5
hands		1.4		2.8	7.0	1.4	1.4	7.0	5.6	2.8	5.6	9.8	2.8	2.8	5.6	5.6	
thi	67.2		22.4	134.4	67.2	67.2	134.4	112.0	89.6	44.8	89.6	44.8	89.6	89.6	44.8		
pop	5.1		1.7	8.5	1.7	6.8	6.8	8.5	6.8	6.8	10.2	11.9		6.8	1.7	3.4	1.7
leg	15.4		7.7	38.5	15.4	30.8	7.7	38.5	30.8		15.4	7.7			30.8		
Tot. Av.	22.7	33.9	14.4	53.4	49.7	66.4	76.0	89.0	64.2	37.7	46.3	51.8	35.7	46.4	56.1	35.2	19.7
Tot. Av.*	21.6	30.7	13.9	52.5	47.9	64.9	76.0	89.0	64.2	35.1	39.4	44.6	35.6	39.6	55.2	34.7	19.0

* Corrected to exclude area covered by protective shorts.

APPENDIX B
Calculation of the Total Damage Index

The following is the method used in calculating the total damage index, using Test No.9 as an example:

It will be seen from Table VII (Test No. 9) that out of seven (7) men, three (3) sustained a mild erythema of the neck (numerical value = 1), two (2) sustained a moderate erythema (numerical value = 2) and two (2) sustained no burn. On a numerical basis for the group, therefore, the average is 1.0 ($\frac{3 \times 1 + 2 \times 2}{7} = 1.0$). On the axillae, one (1) had no burn (=0), four (4) had mild erythema (4X1 = 4) and two (2) had severe erythema (2X3 = 6) giving an average of 1.4 (6.4 = 10; 7 = 1.4). The method is continued until averages for all areas involved are obtained.

The average intensities are then multiplied by the "area factors" given in Table I. Thus, for the neck, the intensity times the "area factor" is 1.0 X 2.4 = 2.4, for the axillae, 1.4 X 2.8 = 3.9 etc. These values (the damage indices for each area) are listed in Table VIII. The sum of the products, then, gives the total damage index for any one test.

APPENDIX C
Calculation of the Percentage of Exposed Area Affected

The following is the method used in calculating the percentage of exposed area affected, using Test No. 9 as an example:

It will be seen from Table VII (Test No. 9) that only two (2) out of seven (7) men sustained burns of the neck of moderate erythema or worse. The two (2) is multiplied by the "area factor" given in Table I to give a value of 4.8. Similarly for the axillae 2 X 2.8 = 5.6, for the shoulder 1 X 5.9 = 5.9, etc. These values are listed in Table IX. The sum of these values, then, gives the total area involved for the group, which, divided by the number of men in the group gives the average percentage of area involved per man.

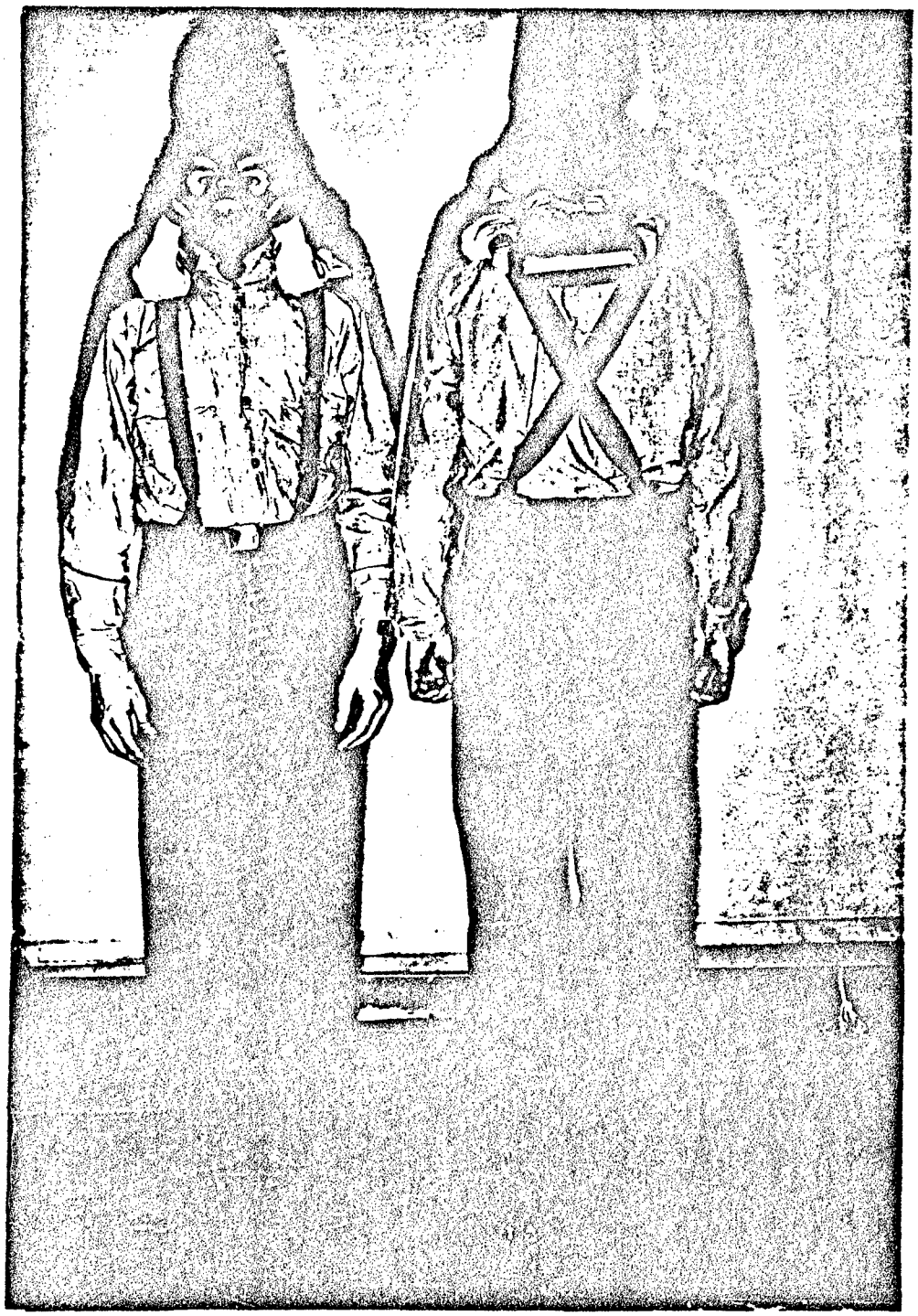

FIG. 1

Men Dressed for Basic Tests

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PLATE I

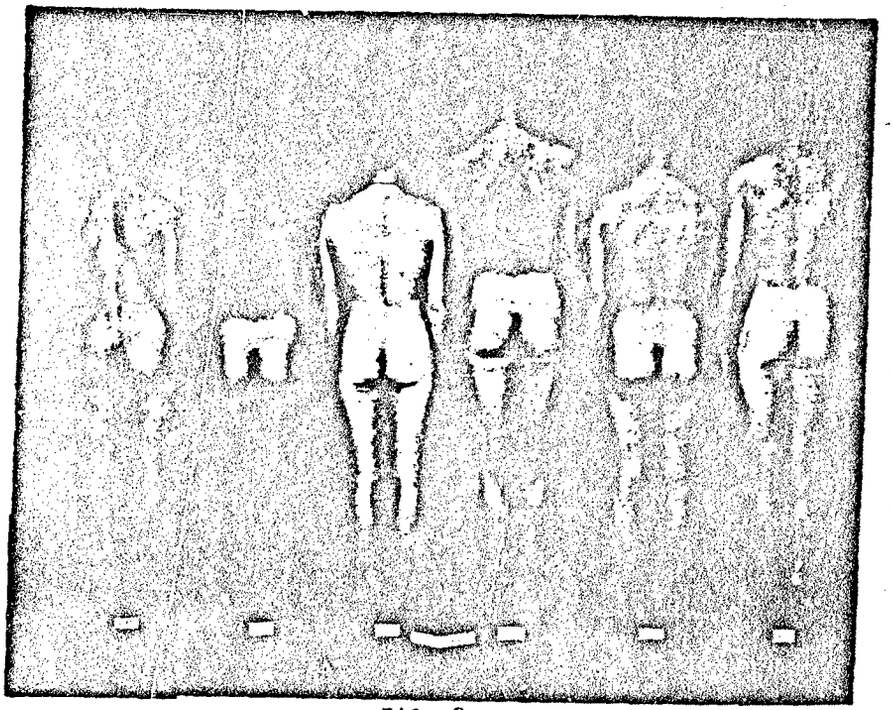

FIG. 2

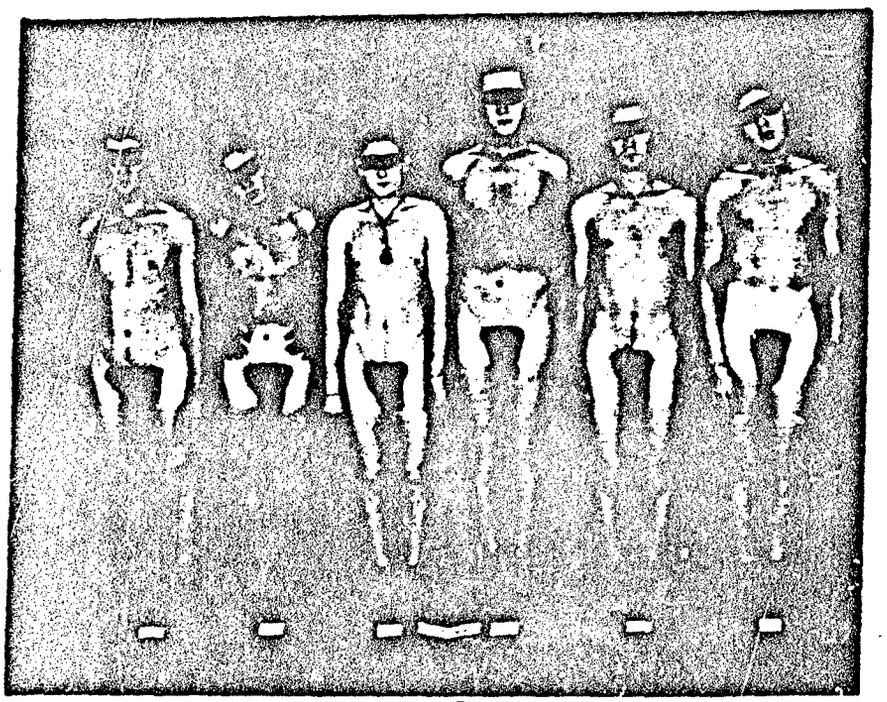

FIG. 3

Subjects 429, 430, 431: H CT 300 90°F. 65% RH–7 Days– Test No. 23

Subjects 435, 436, 437: H CT 400 70°F. 62% RH–4 Days– Test No. 26

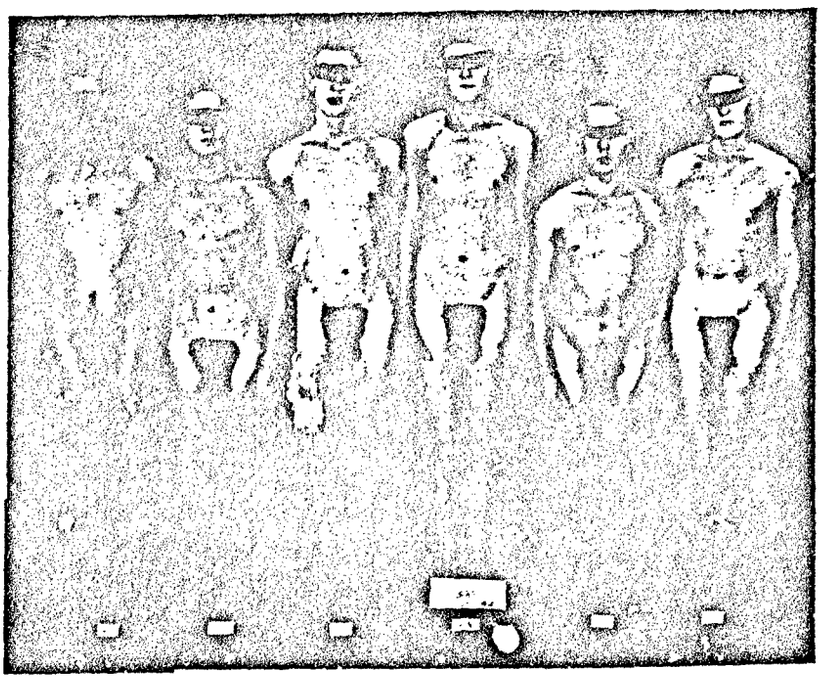

FIG. 4
H CT 300
Subjects 423, 424, 425: 70°F. 60% RH Test No. 17
Subjects 429, 430, 431: 90°F. 65% RH Test No. 23
4 Days

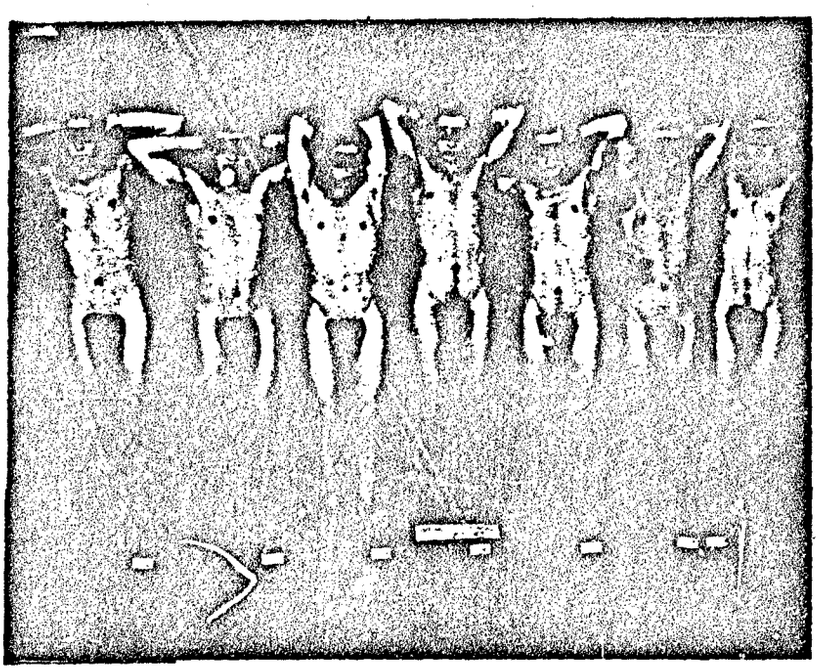

FIG. 5
H CT 600
70°F. 52% RH
Test No. 32
12 Days

PLATE 3

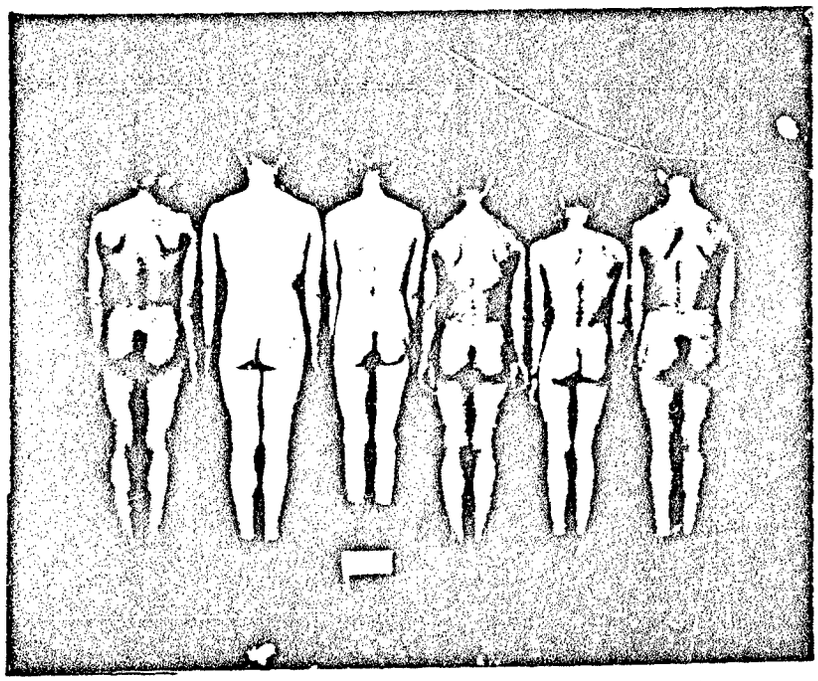

FIG. 6

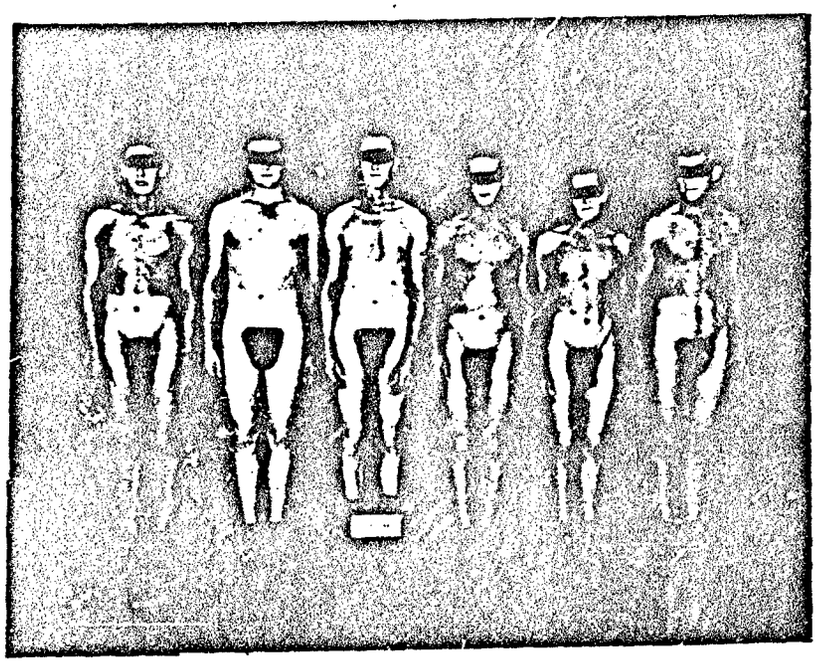

FIG. 7
H CT 250
90°F. 65% RH
Test No. 16
6 Days

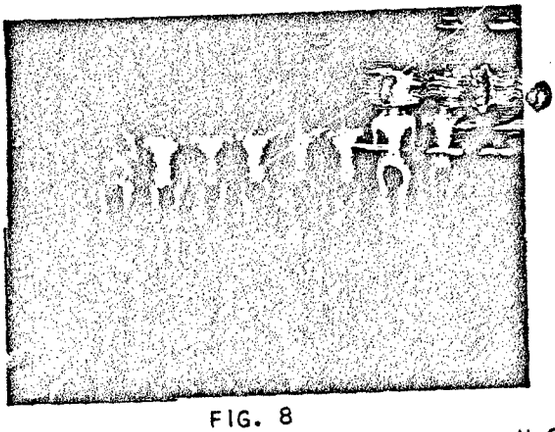

FIG. 8

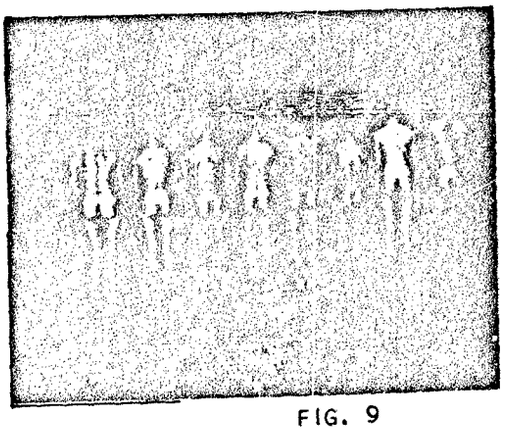

FIG. 9

H CT 300
85°F. 36% RH
Test No. 19
5 Days

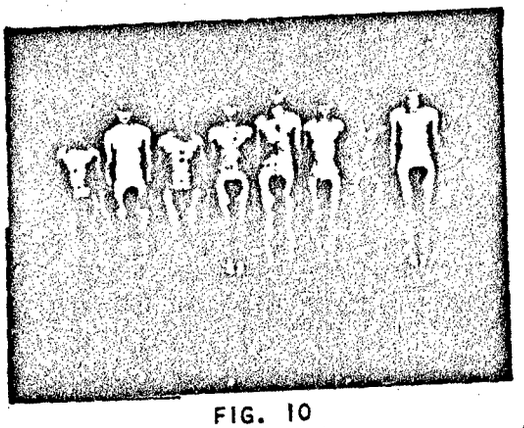

FIG. 10

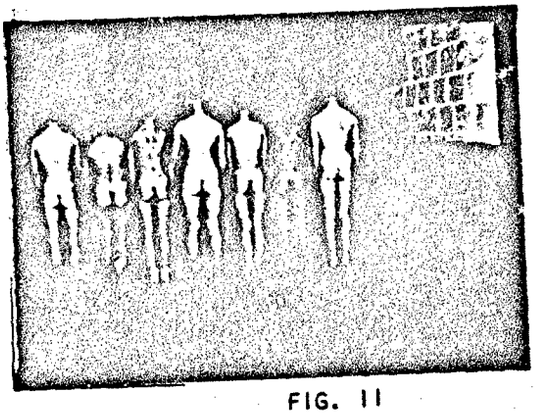

FIG. 11

H CT 300
85°F. 77% RH
Test No. 20
5 Days

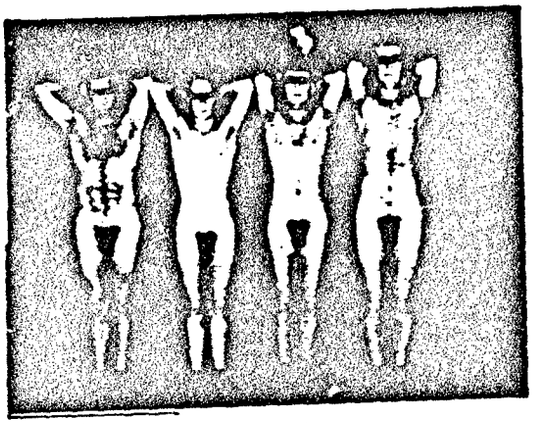

FIG. 12

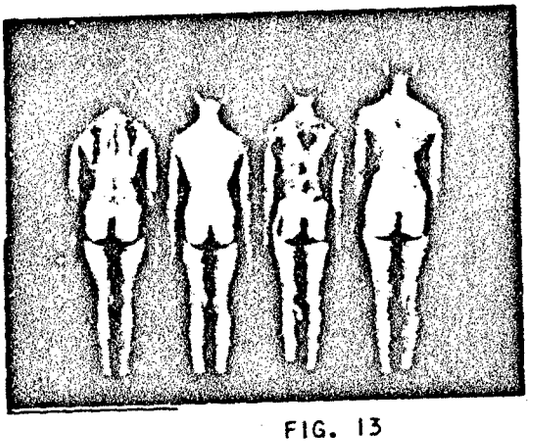

FIG. 13

H CT 300
85°F.
The Two Subjects on Left at 36% RH Test No. 19
The Two Subjects on Right at 77% RH Test No. 20
7 Days

PLATE 5

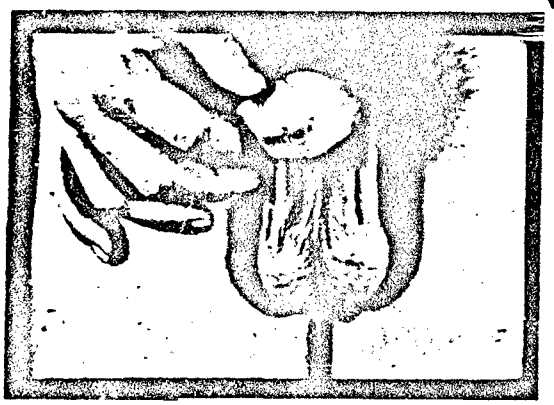

FIG. 14 6 Days

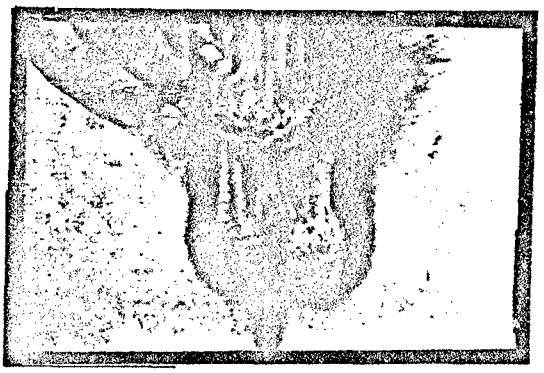

FIG. 15 14 Days

Subject 518
H CT 600
60°F. 62% RH
Test No. 30

FIG. 16 10 Days

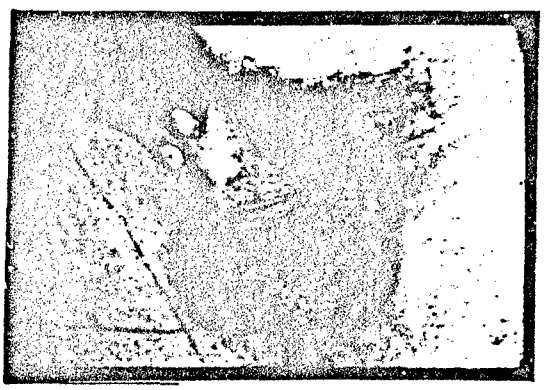

FIG. 17 37 Days

Subject 492
H CT 500
70°F. 48% RH
Test No. 28

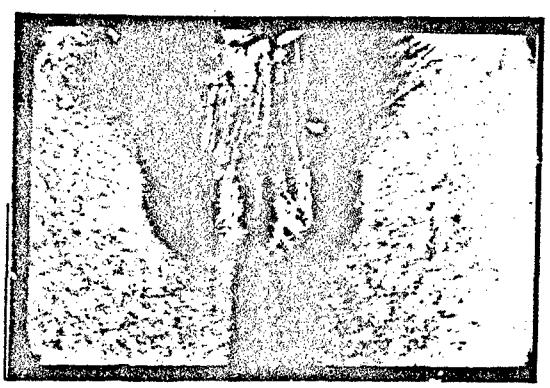

FIG. 18 38 Days
Subject 490
H CT 500
70°F. 48% RH
Test No. 28

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PLATE 6

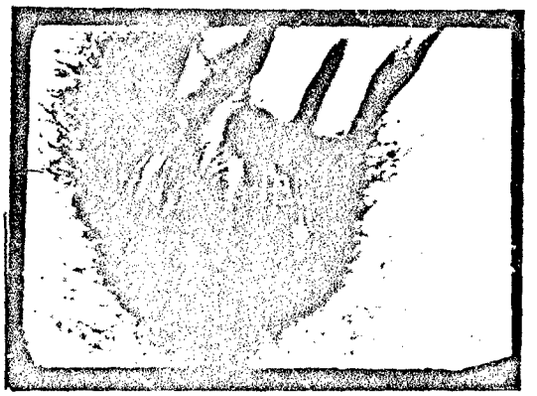


FIG. 19 3 Days

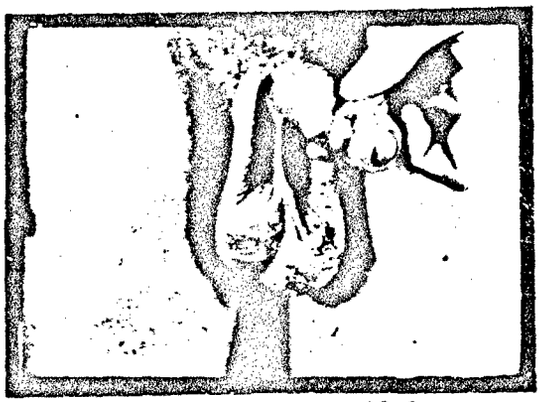


FIG. 22 10 Days

FIG. 20 4 Days

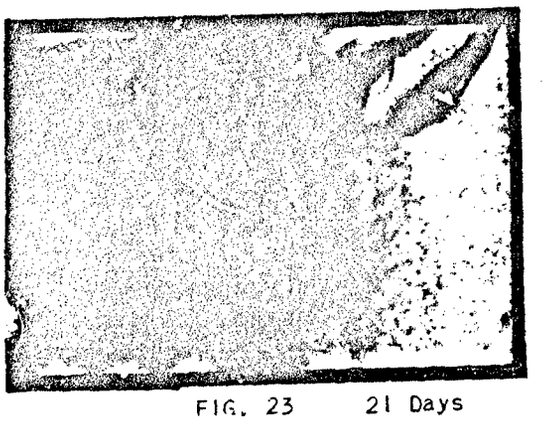


FIG. 23 21 Days

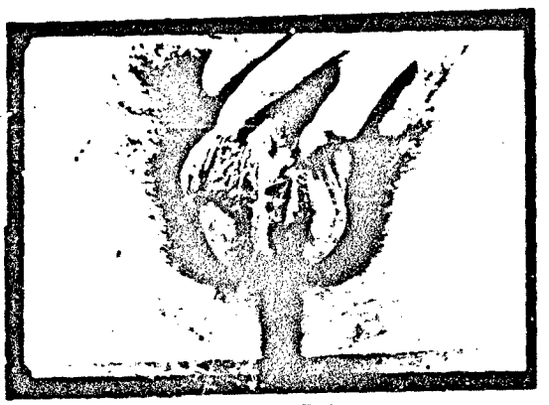


FIG. 21 5 Days

Subject 520
H CT 600
60°F. 62% RH
Test No. 30

FIG. 24 31 Days

Subject 486
H CT 500
70°F. 48% RH
Test No. 28

PLATE 7

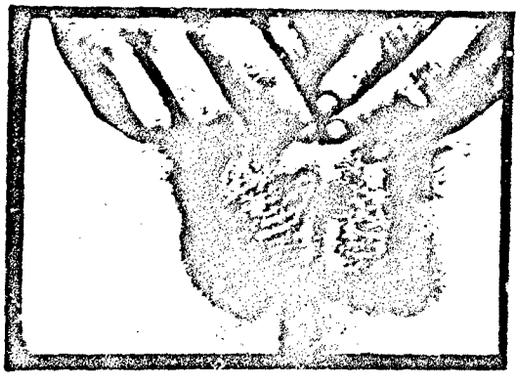


FIG. 25 3 Days
H CT 600
60°F. 62% RH
Subject 522
Test No. 30

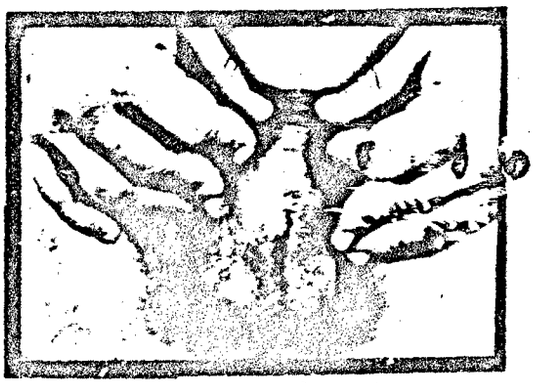


FIG. 28* 4 Days

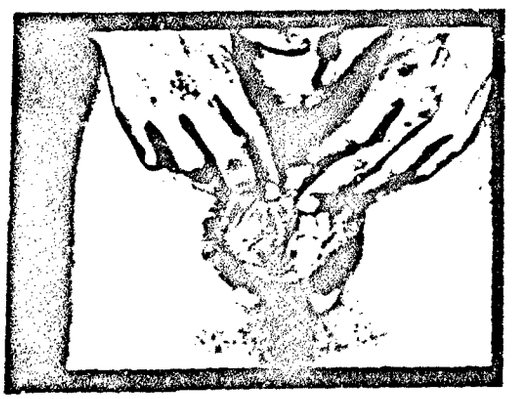


FIG. 26 14 Days
H CT 500
70°F. 48% RH
Subject 487
Test No. 28

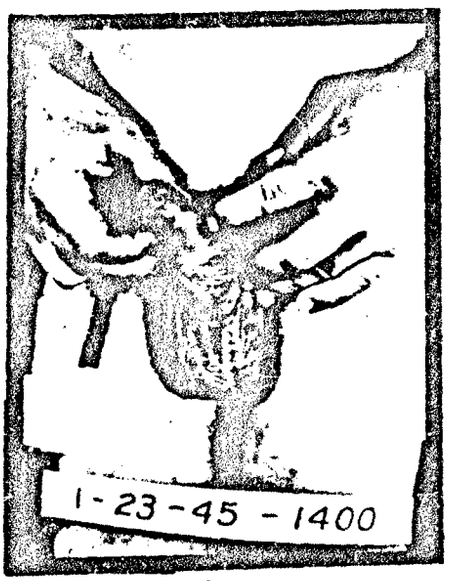


FIG. 29* 11 Days

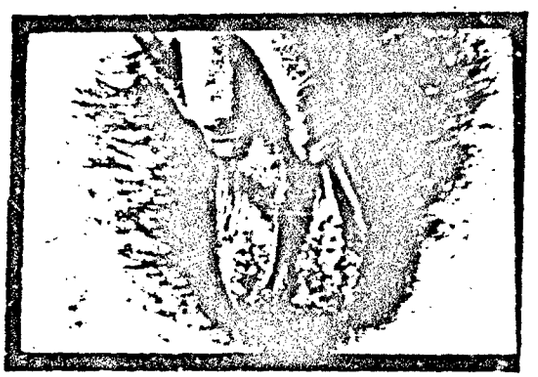


FIG. 27 17 Days
H CT 200
100°F. 67% RH
Subject 587
Test No. 6

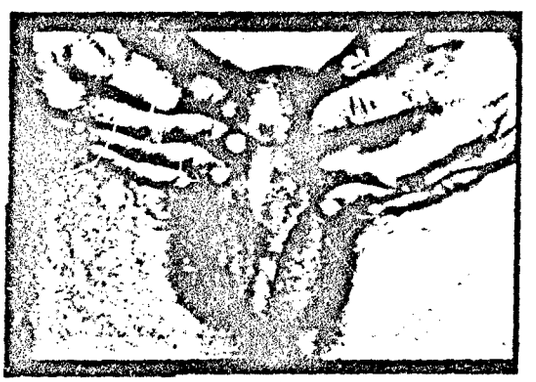


FIG. 30* 42 Days
H CT 600
60°F. 62% RH
*Subject 521
Test No. 30

PLATE 8

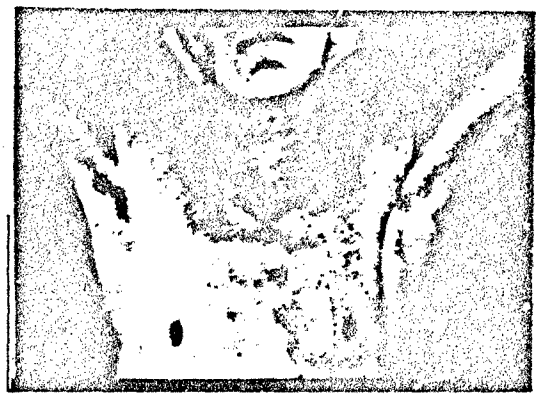


FIG. 31
H CT 200
100°F. 66% RH
Subject 590
Test No. 14
12 Days

FIG. 32
H CT 600
60°F. 57% RH
Subject 512
Test No. 29
15 Days

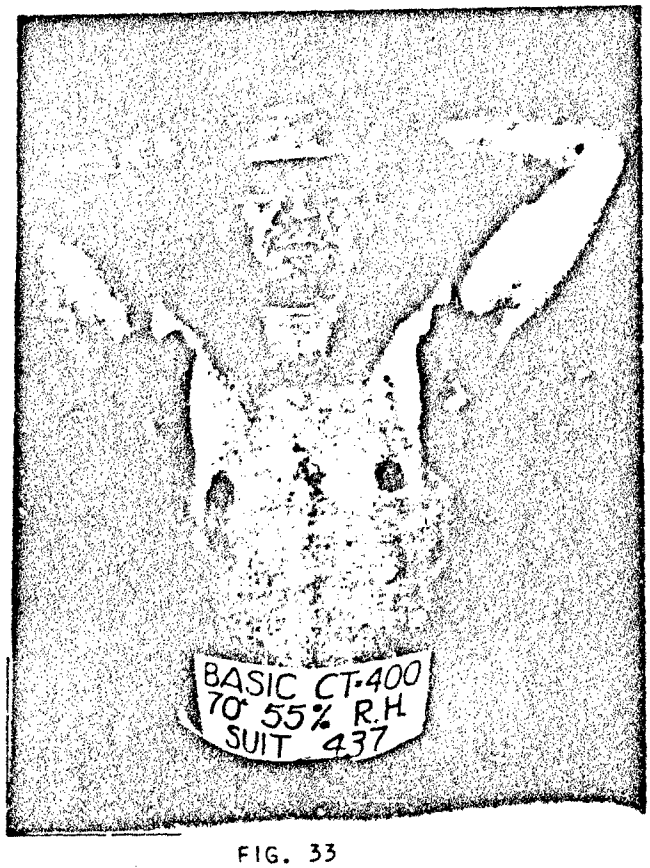


FIG. 33
H CT 400
70°F. 62% RH
Subject 437
Test No. 26
8 Days

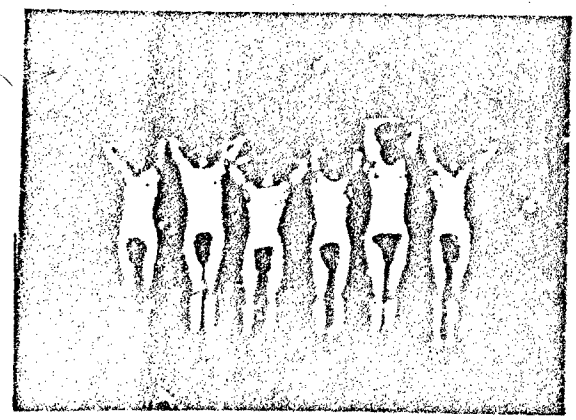


FIG. 34
H CT 300
70°F. 45% RH
Left half of skivvy shirt moistened with artificial sweat; right half, dry control.
9 Days

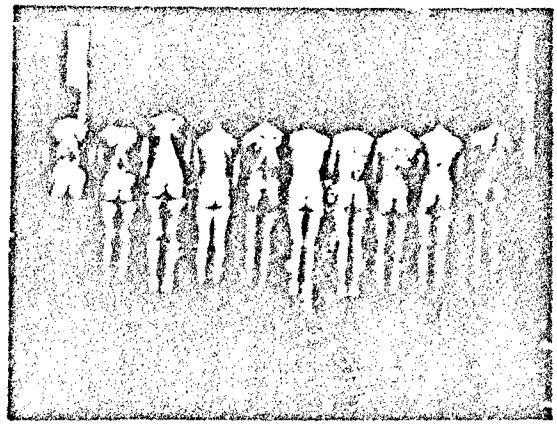


FIG. 35
H CT 300
90°F. 65% RH
Tests No. 24, 25
Five men on right; precooled. Test 25
Five men on left; controls. Test 24
Both groups in chamber together.
14 Days

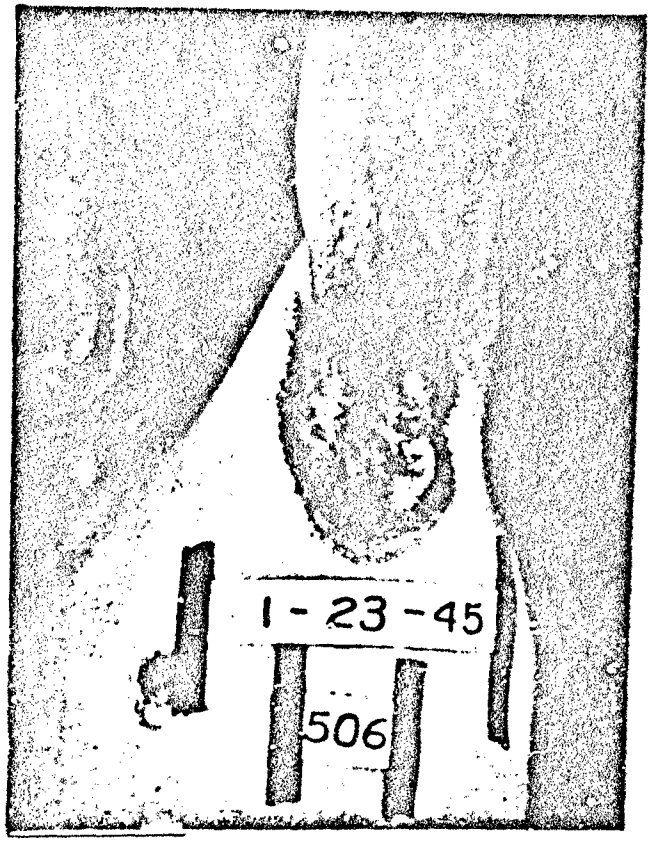


FIG. 36
H CT 600
70°F. 52% RH
Subject 506
Test No. 32
13 Days

FIG. 37

FIG. 38

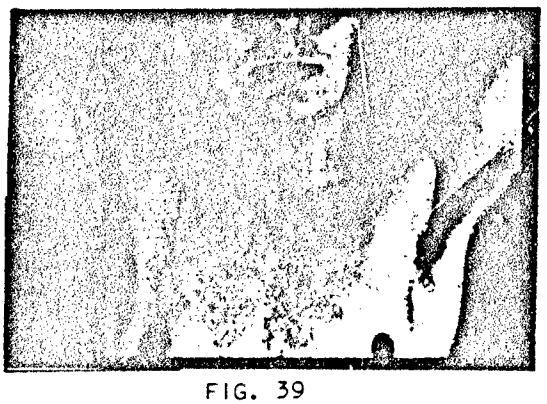


FIG. 39

H CT 500
70°F 48% RH
Test No. 28*
11 Days

*The left axillae were treated with aluminum chloride; the right axillae were normal controls.

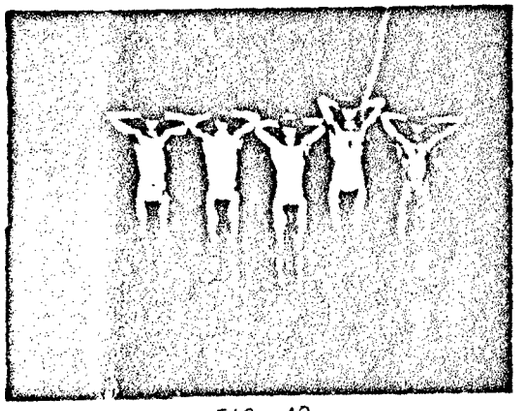


FIG. 40

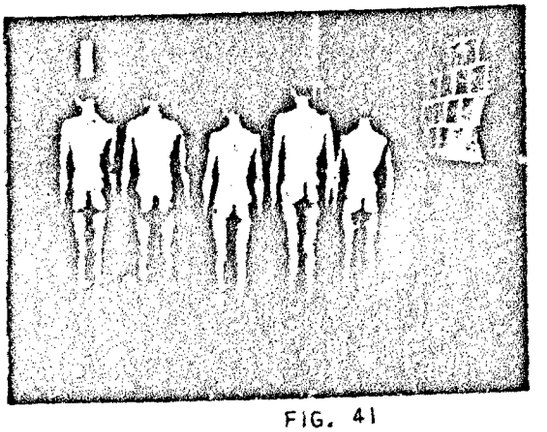


FIG. 41

70°F. 51% RH

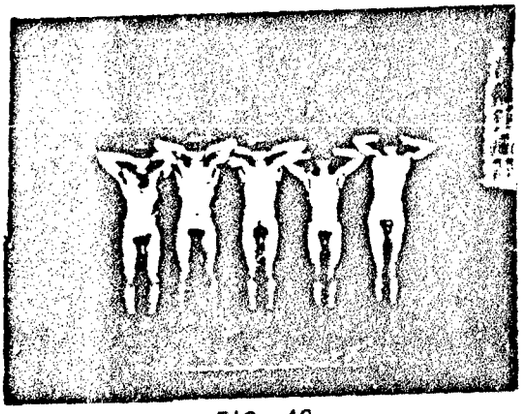


FIG. 42

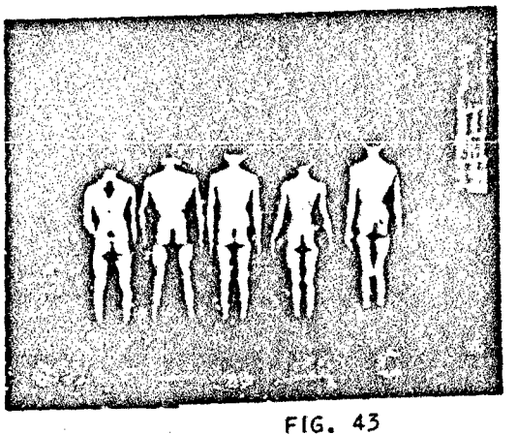


FIG. 43

79°F. 86% RH

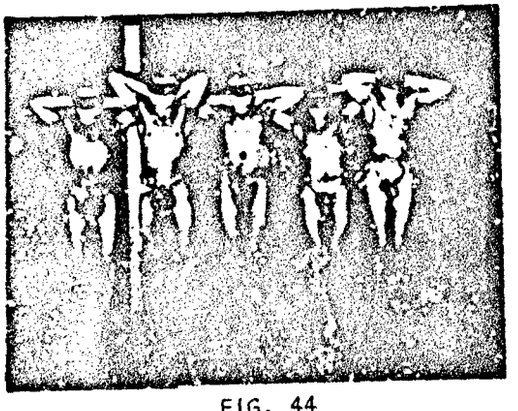


FIG. 44

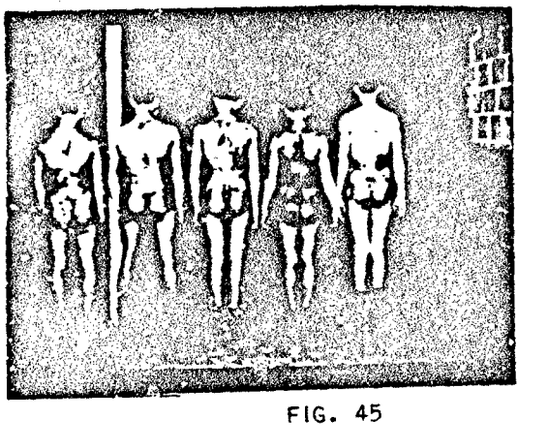


FIG. 45

90°F. 62% RH

SWEAT TESTS

The men wore masks and dungarees and were in the chamber one hour at conditions given above. Starch-iodine method. Photographed immediately after test.

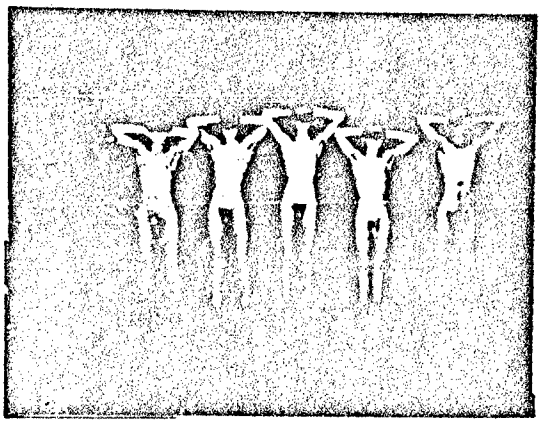


FIG. 46

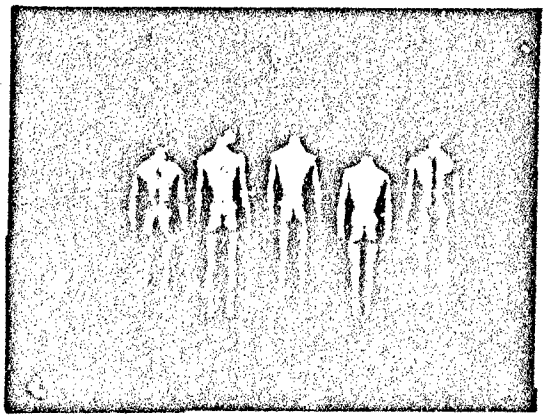


FIG. 47

85°F. 36% RH

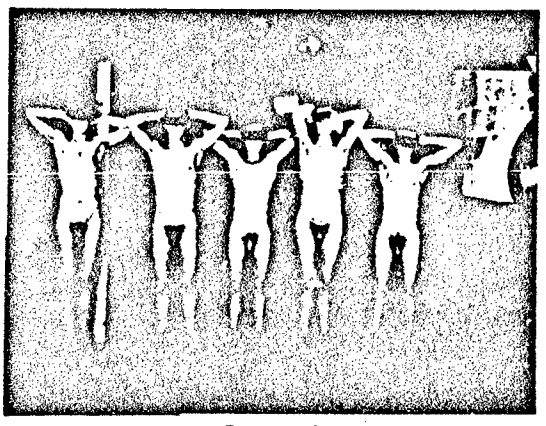


FIG. 48

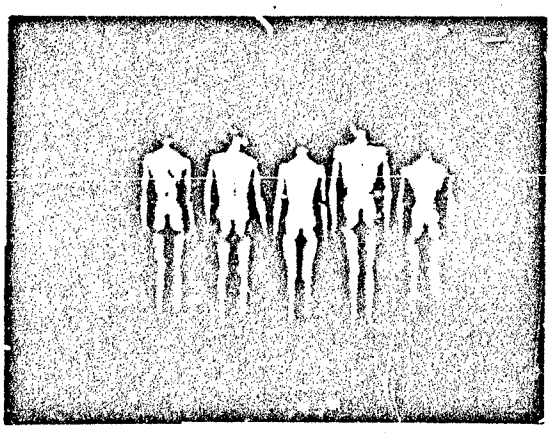


FIG. 49

85°F. 36% RH

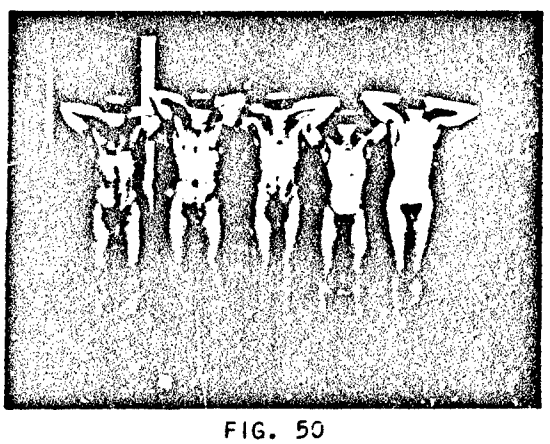


FIG. 50

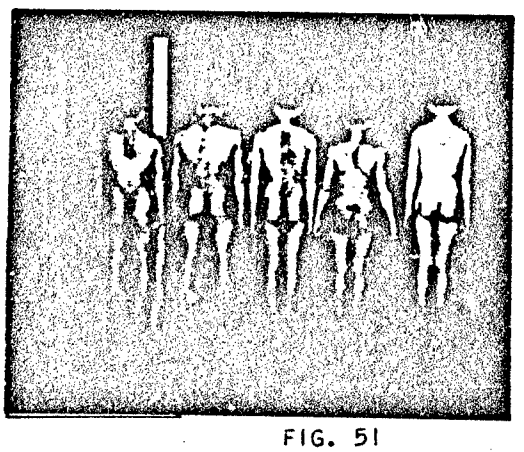


FIG. 51

85°F. 75% RH

SWEAT TESTS

The men wore masks and dungarees and were in the chamber one hour at conditions given above. Starch-iodine method. Photographed immediately after test.

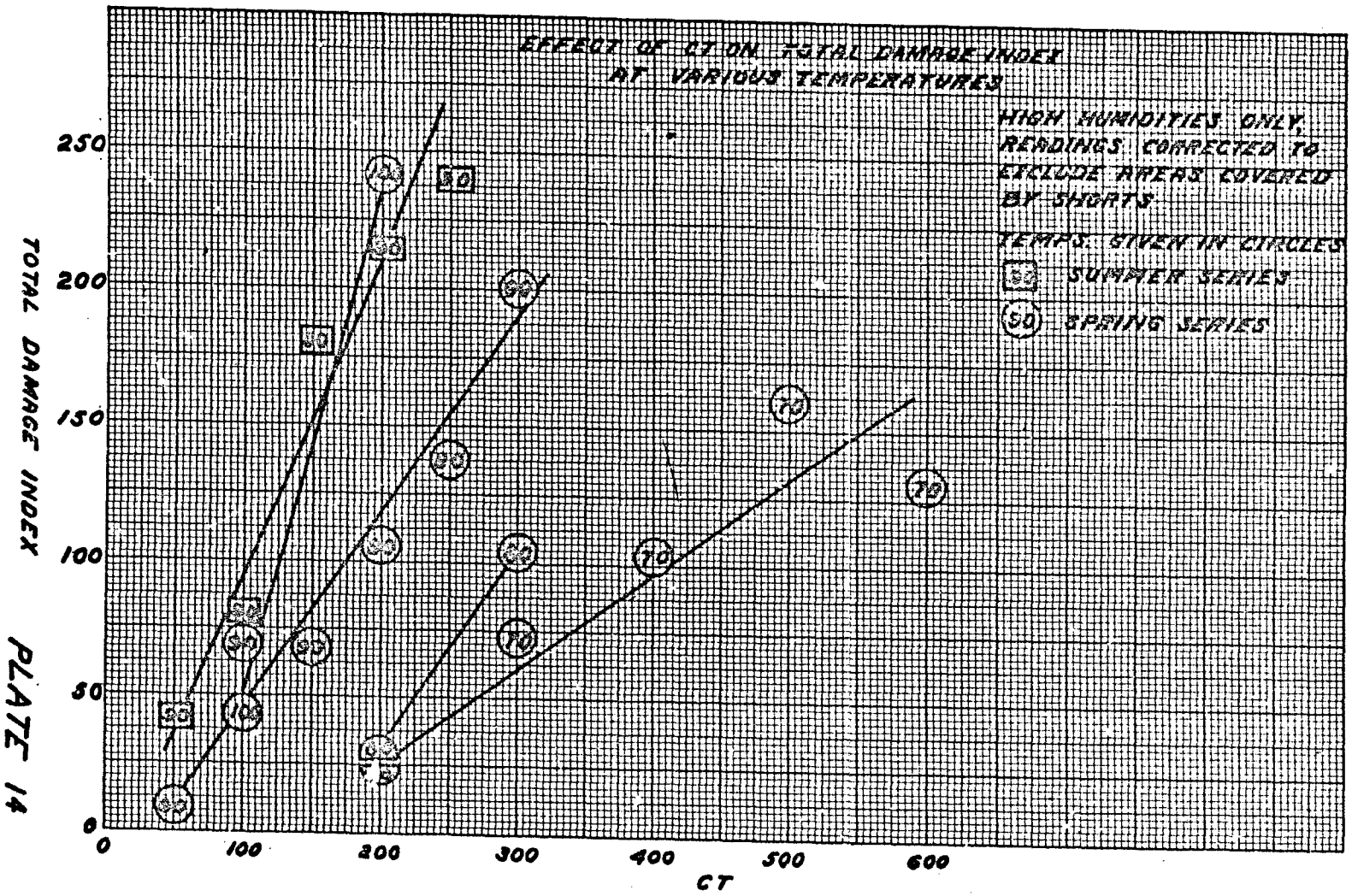

EFFECT OF CT ON TOTAL DAMAGE INDEX
AT VARIOUS TEMPERATURES
HIGH HUMIDITIES ONLY,
READINGS CORRECTED TO
EXCLUDE AREAS COVERED
BY SHORTS
TEMPS. GIVEN IN CIRCLES
50 SUMMER SERIES
(50) SPRING SERIES
TOTAL DAMAGE INDEX
CT
0
50
100
150
200
250
0
100
200
300
400
500
600

PLATE 14

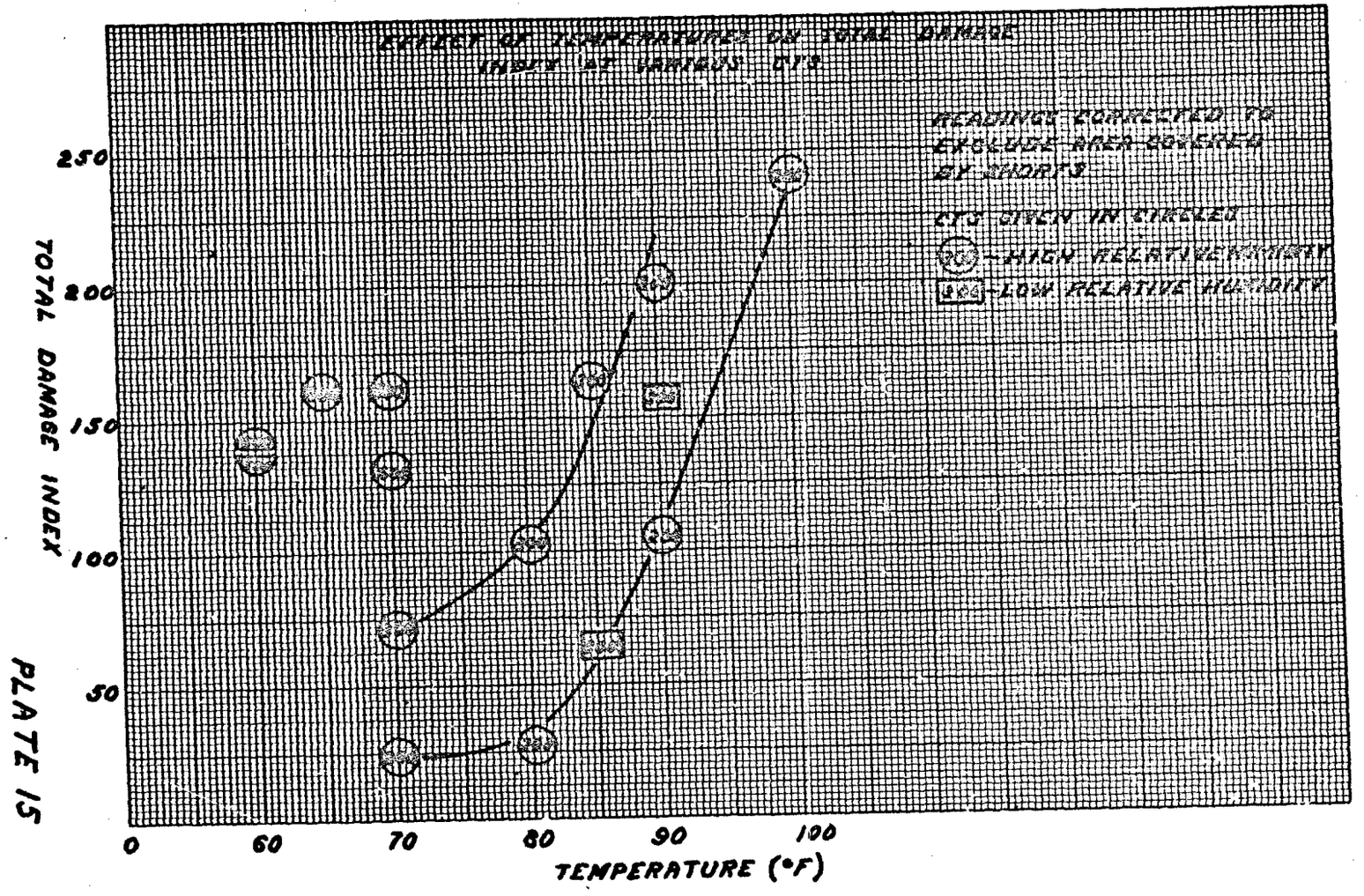
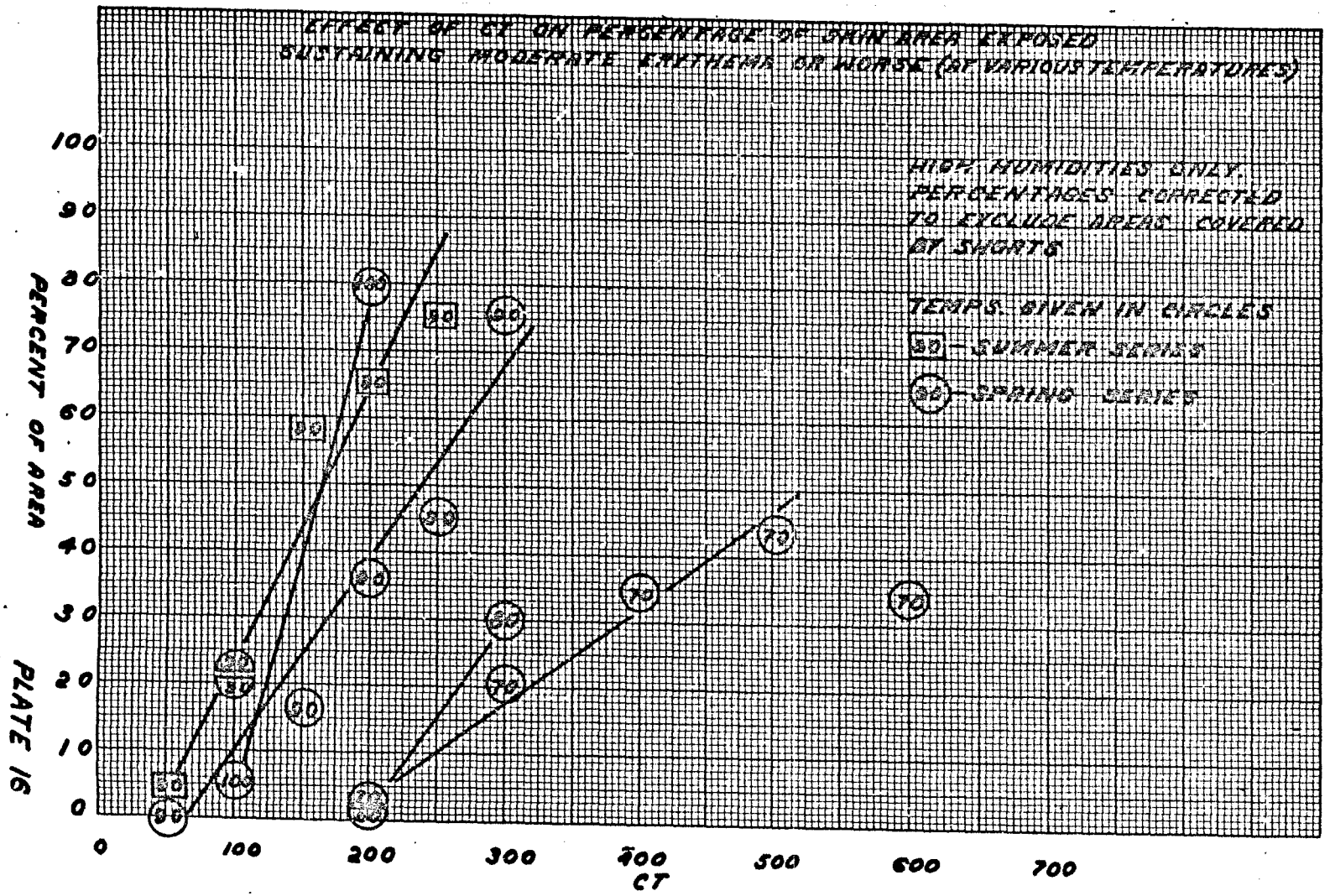

EFFECT OF FLUCTUATIONS ON TOTAL DAMAGE INDEX AT VARIOUS CITIES
READINGS CORRECTED TO EXCLUDE AREA COVERED BY SHORTS
CITY GIVEN IN CIRCLES
(90) - HIGH RELATIVE HUMIDITY
[90] - LOW RELATIVE HUMIDITY
TOTAL DAMAGE INDEX
250
200
150
100
50
0
60
70
80
90
100
TEMPERATURE (°F)

PLATE 15

PLATE 16


EFFECT OF CT ON PERCENTAGE OF SKIN AREA EXPOSED SUSTAINING MODERATE ERYTHEMA OR WORSE (AT VARIOUS TEMPERATURES)
HIGH HUMIDITIES ONLY
PERCENTAGES CORRECTED TO EXCLUDE AREAS COVERED BY SHORTS
TEMPS. GIVEN IN CIRCLES
90 — SUMMER SERIES
90 — SPRING SERIES
PERCENT OF AREA
CT
0
10
20
30
40
50
60
70
80
90
100
0
100
200
300
400
500
600
700

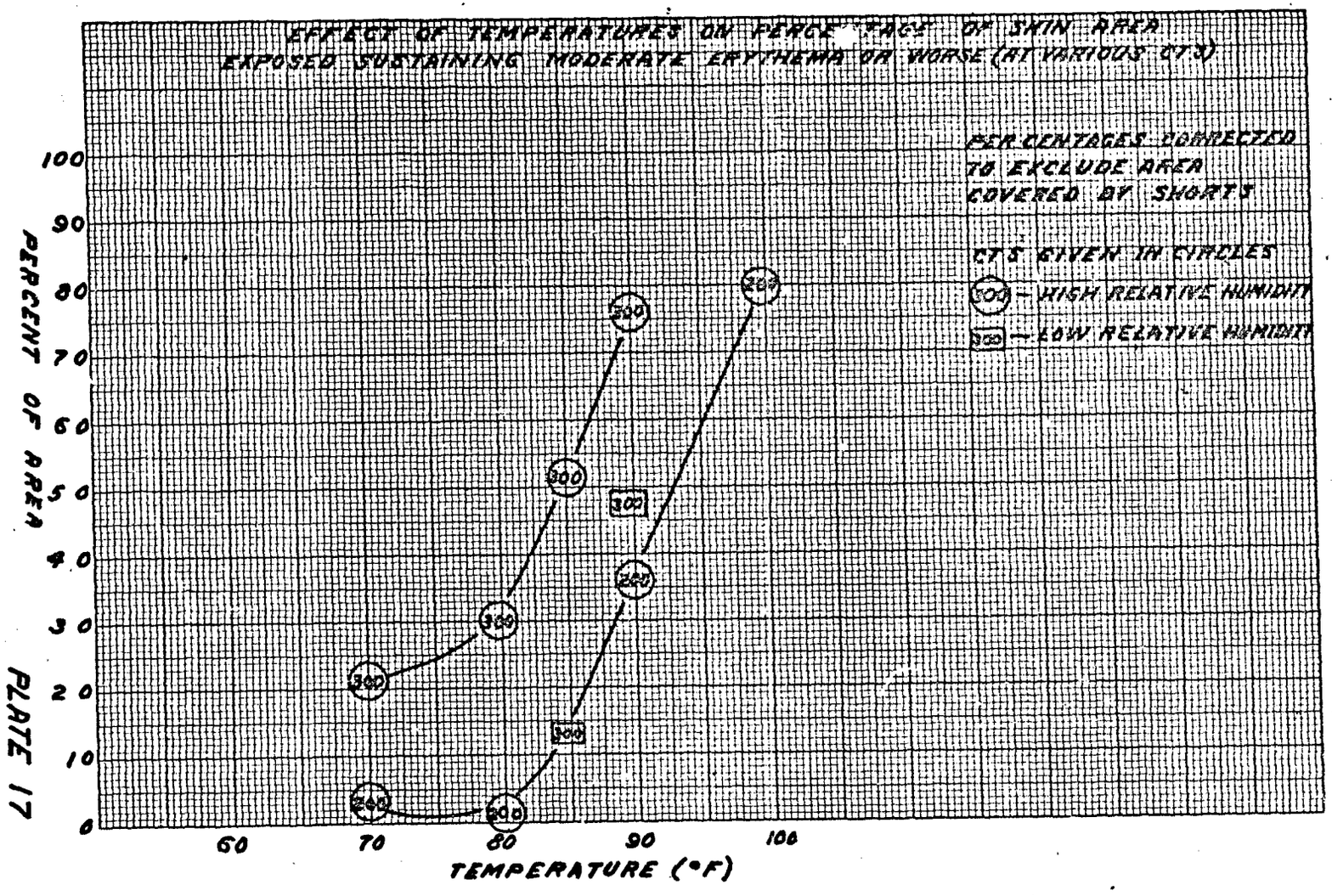

EFFECT OF TEMPERATURES ON PERCENTAGE OF SKIN AREA EXPOSED SUSTAINING MODERATE ERYTHEMA OR WORSE (AT VARIOUS CTS)
PERCENTAGES CORRECTED TO EXCLUDE AREA COVERED BY SHORTS
CTS GIVEN IN CIRCLES
(300) — HIGH RELATIVE HUMIDITY
[300] — LOW RELATIVE HUMIDITY
PERCENT OF AREA
100
90
80
70
60
50
40
30
20
10
0
60
70
80
90
100
TEMPERATURE (°F)
300
300
300
300
300
300
300
300

PLATE 17

END

FILMED

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DTIC